model_training

February 20, 2019

1 Follow-Me Project

Congratulations on reaching the final project of the Robotics Nanodegree!

Previously, you worked on the Semantic Segmentation lab where you built a deep learning network that locates a particular human target within an image. For this project, you will utilize what you implemented and learned from that lab and extend it to train a deep learning model that will allow a simulated quadcopter to follow around the person that it detects!

Most of the code below is similar to the lab with some minor modifications. You can start with your existing solution, and modify and improve upon it to train the best possible model for this task.

You can click on any of the following to quickly jump to that part of this notebook: 1. Section **??** 2. Section **??** 3. Section **??** 4. Section 1.4 5. Section 1.5 6. Section 1.6

1.1 Data Collection

We have provided you with a starting dataset for this project. Download instructions can be found in the README for this project's repo. Alternatively, you can collect additional data of your own to improve your model. Check out the "Collecting Data" section in the Project Lesson in the Classroom for more details!

In [1]:
```
import os
import glob
import sys
import tensorflow as tf

from scipy import misc
import numpy as np

from tensorflow.contrib.keras.python import keras
from tensorflow.contrib.keras.python.keras import layers, models

from tensorflow import image

from utils import scoring_utils
from utils.separable_conv2d import SeparableConv2DKeras, BilinearUpSampling2D
from utils import data_iterator
from utils import plotting_tools
from utils import model_tools
```

1.2 FCN Layers

In the Classroom, we discussed the different layers that constitute a fully convolutional network (FCN). The following code will introduce you to the functions that you need to build your semantic segmentation model.

1.2.1 Separable Convolutions

The Encoder for your FCN will essentially require separable convolution layers, due to their advantages as explained in the classroom. The 1x1 convolution layer in the FCN, however, is a regular convolution. Implementations for both are provided below for your use. Each includes batch normalization with the ReLU activation function applied to the layers.

```
In [2]: def separable_conv2d_batchnorm(input_layer, filters, strides=1):
            output_layer = SeparableConv2DKeras(filters=filters,kernel_size=3, strides=strides,
                                        padding='same', activation='relu')(input_layer)

            output_layer = layers.BatchNormalization()(output_layer)
            return output_layer

        def conv2d_batchnorm(input_layer, filters, kernel_size=3, strides=1):
            output_layer = layers.Conv2D(filters=filters, kernel_size=kernel_size, strides=strid
                               padding='same', activation='relu')(input_layer)

            output_layer = layers.BatchNormalization()(output_layer)
            return output_layer
```

1.2.2 Bilinear Upsampling

The following helper function implements the bilinear upsampling layer. Upsampling by a factor of 2 is generally recommended, but you can try out different factors as well. Upsampling is used in the decoder block of the FCN.

```
In [3]: def bilinear_upsample(input_layer):
            output_layer = BilinearUpSampling2D((2,2))(input_layer)
            return output_layer
```

1.3 Build the Model

In the following cells, you will build an FCN to train a model to detect and locate the hero target within an image. The steps are: - Create an `encoder_block` - Create a `decoder_block` - Build the FCN consisting of encoder block(s), a 1x1 convolution, and decoder block(s). This step requires experimentation with different numbers of layers and filter sizes to build your model.

1.3.1 Encoder Block

Create an encoder block that includes a separable convolution layer using the `separable_conv2d_batchnorm()` function. The `filters` parameter defines the size or depth of the output layer. For example, 32 or 64.

```
In [4]: def encoder_block(input_layer, filters, strides):

            # Create a separable convolution layer using the separable_conv2d_batchnorm() functi
            output_layer = separable_conv2d_batchnorm(input_layer, filters, strides)

            return output_layer
```

1.3.2 Decoder Block

The decoder block is comprised of three parts: - A bilinear upsampling layer using the upsample_bilinear() function. The current recommended factor for upsampling is set to 2. - A layer concatenation step. This step is similar to skip connections. You will concatenate the upsampled small_ip_layer and the large_ip_layer. - Some (one or two) additional separable convolution layers to extract some more spatial information from prior layers.

```
In [5]: def decoder_block(small_ip_layer, large_ip_layer, filters):

            # Upsample the small input layer using the bilinear_upsample() function.
            upsampled_small_ip_layer = bilinear_upsample(small_ip_layer)

            # Concatenate the upsampled and large input layers using layers.concatenate
            output_layer = layers.concatenate([upsampled_small_ip_layer, large_ip_layer])

            # Add some number of separable convolution layers
            output_layer = separable_conv2d_batchnorm( output_layer, filters, strides=1)

            return output_layer
```

1.3.3 Model

Now that you have the encoder and decoder blocks ready, go ahead and build your FCN architecture!

There are three steps: - Add encoder blocks to build the encoder layers. This is similar to how you added regular convolutional layers in your CNN lab. - Add a 1x1 Convolution layer using the conv2d_batchnorm() function. Remember that 1x1 Convolutions require a kernel and stride of 1. - Add decoder blocks for the decoder layers.

```
In [6]: def fcn_model(inputs, num_classes):

            # Remember that with each encoder layer, the depth of your model (the number of filt
            encoder1 = encoder_block(inputs, filters=64, strides=2)
            print('layer1', encoder1)
            encoder2 = encoder_block(encoder1, filters=64, strides=2)
            print('layer2', encoder2)
            encoder3 = encoder_block(encoder2, filters=64, strides=2)
            print('layer3', encoder3)
            encoder4 = encoder_block(encoder3, filters=128, strides=2)
            print('layer4', encoder4)
```

```
    # Add 1x1 Convolution layer using conv2d_batchnorm().
    onebyone_convolution_layer = conv2d_batchnorm(encoder4, filters=128, kernel_size=1,
    print('layer5', onebyone_convolution_layer)

    # Add the same number of Decoder Blocks as the number of Encoder Blocks
    decoder1 = decoder_block(onebyone_convolution_layer, encoder3, filters= 128)
    print('layer6', decoder1)
    decoder2 = decoder_block(decoder1, encoder2, filters=64)
    print('layer7', decoder2)
    decoder3 = decoder_block(decoder2, encoder1, filters=64)
    print('layer8', decoder3)
    decoder4 = decoder_block(decoder3, inputs, filters=64)
    print('layer9', decoder4)
    x = decoder4


    # The function returns the output layer of your model. "x" is the final layer obtain
    return layers.Conv2D(num_classes, 1, activation='softmax', padding='same')(x)
```

1.4 Training

The following cells will use the FCN you created and define an ouput layer based on the size of the processed image and the number of classes recognized. You will define the hyperparameters to compile and train your model.

Please Note: For this project, the helper code in `data_iterator.py` will resize the copter images to 160x160x3 to speed up training.

In [7]:
```
"""
DON'T MODIFY ANYTHING IN THIS CELL THAT IS BELOW THIS LINE
"""


image_hw = 160
image_shape = (image_hw, image_hw, 3)
inputs = layers.Input(image_shape)
num_classes = 3

# Call fcn_model()
output_layer = fcn_model(inputs, num_classes)
```

```
layer1 Tensor("batch_normalization/batchnorm/add_1:0", shape=(?, 80, 80, 64), dtype=float32)
layer2 Tensor("batch_normalization_2/batchnorm/add_1:0", shape=(?, 40, 40, 64), dtype=float32)
layer3 Tensor("batch_normalization_3/batchnorm/add_1:0", shape=(?, 20, 20, 64), dtype=float32)
layer4 Tensor("batch_normalization_4/batchnorm/add_1:0", shape=(?, 10, 10, 128), dtype=float32)
layer5 Tensor("batch_normalization_5/batchnorm/add_1:0", shape=(?, 10, 10, 128), dtype=float32)
layer6 Tensor("batch_normalization_6/batchnorm/add_1:0", shape=(?, 20, 20, 128), dtype=float32)
layer7 Tensor("batch_normalization_7/batchnorm/add_1:0", shape=(?, 40, 40, 64), dtype=float32)
layer8 Tensor("batch_normalization_8/batchnorm/add_1:0", shape=(?, 80, 80, 64), dtype=float32)
layer9 Tensor("batch_normalization_9/batchnorm/add_1:0", shape=(?, 160, 160, 64), dtype=float32)
```

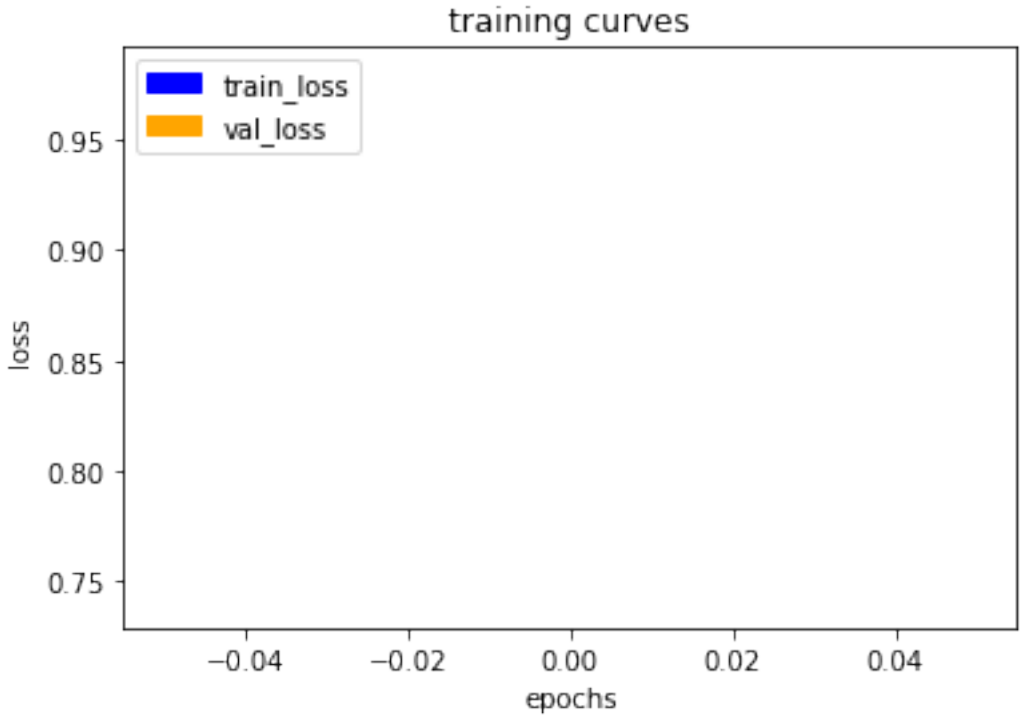
1.4.1 Hyperparameters

Define and tune your hyperparameters. - **batch_size**: number of training samples/images that get propagated through the network in a single pass. - **num_epochs**: number of times the entire training dataset gets propagated through the network. - **steps_per_epoch**: number of batches of training images that go through the network in 1 epoch. We have provided you with a default value. One recommended value to try would be based on the total number of images in training dataset divided by the batch_size. - **validation_steps**: number of batches of validation images that go through the network in 1 epoch. This is similar to steps_per_epoch, except validation_steps is for the validation dataset. We have provided you with a default value for this as well. - **workers**: maximum number of processes to spin up. This can affect your training speed and is dependent on your hardware. We have provided a recommended value to work with.

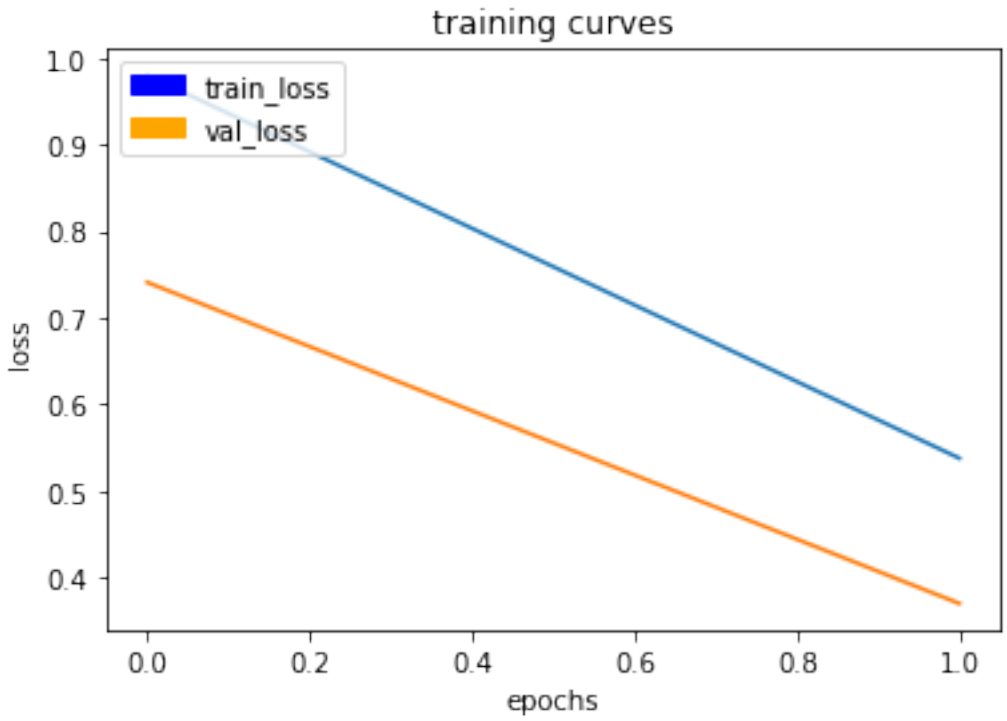
In [8]:
```
learning_rate = 0.001
batch_size = 100
num_epochs = 200
steps_per_epoch = 41
validation_steps = 12
workers = 4
```

In [9]:
```
"""
DON'T MODIFY ANYTHING IN THIS CELL THAT IS BELOW THIS LINE
"""

from workspace_utils import active_session
# Keeping Your Session Active
with active_session():
    # Define the Keras model and compile it for training
    model = models.Model(inputs=inputs, outputs=output_layer)

    model.compile(optimizer=keras.optimizers.Adam(learning_rate), loss='categorical_cros

    # Data iterators for loading the training and validation data
    train_iter = data_iterator.BatchIteratorSimple(batch_size=batch_size,
                                                   data_folder=os.path.join('..', 'data'
                                                   image_shape=image_shape,
                                                   shift_aug=True)

    val_iter = data_iterator.BatchIteratorSimple(batch_size=batch_size,
                                                 data_folder=os.path.join('..', 'data',
                                                 image_shape=image_shape)

    logger_cb = plotting_tools.LoggerPlotter()
    callbacks = [logger_cb]

    model.fit_generator(train_iter,
                        steps_per_epoch = steps_per_epoch, # the number of batches per e
                        epochs = num_epochs, # the number of epochs to train for,
                        validation_data = val_iter, # validation iterator
```

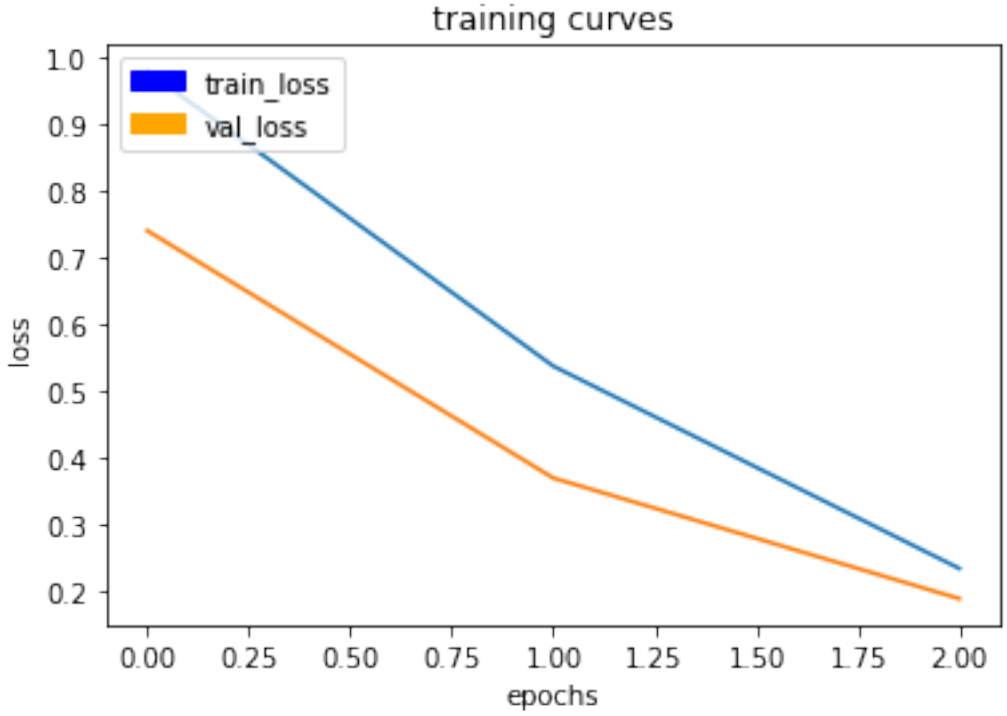
```
                                validation_steps = validation_steps, # the number of batches to
                                callbacks=callbacks,
                                workers = workers)

Epoch 1/200
40/41 [============================>.] - ETA: 1s - loss: 0.9818
```



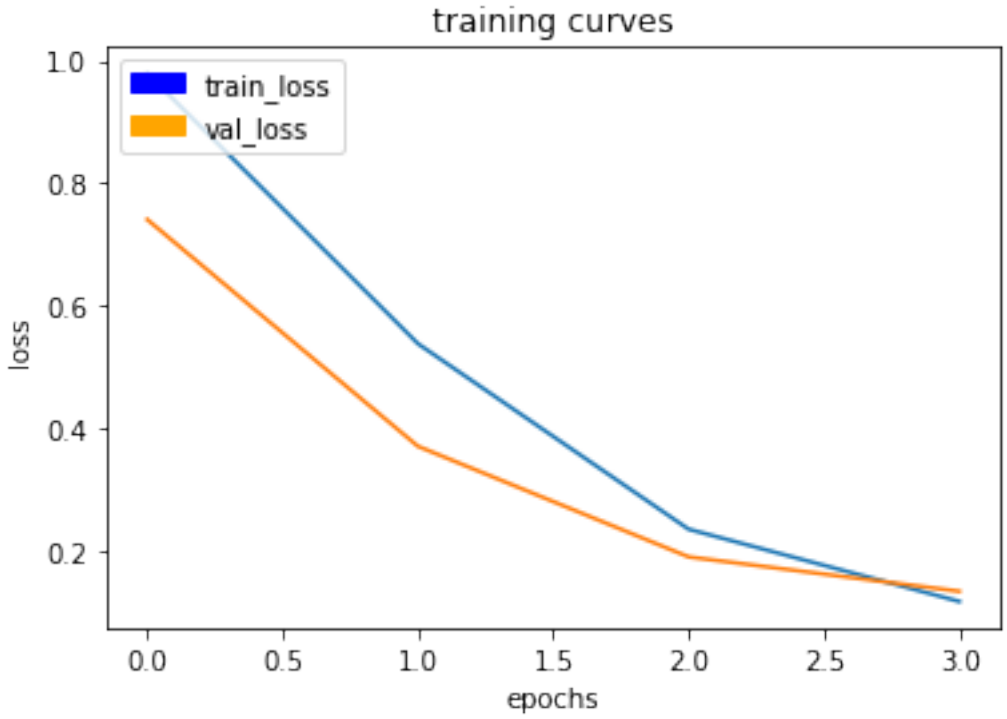

```
41/41 [==============================] - 62s - loss: 0.9761 - val_loss: 0.7409
Epoch 2/200
40/41 [============================>.] - ETA: 1s - loss: 0.5427
```



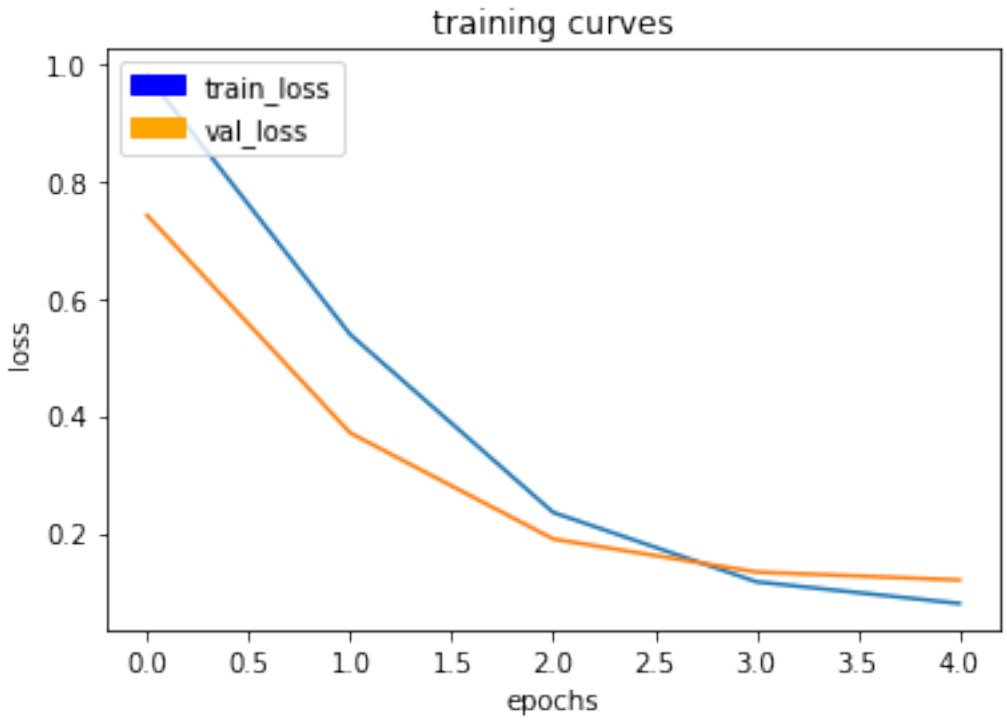

```
41/41 [==============================] - 58s - loss: 0.5380 - val_loss: 0.3705
Epoch 3/200
40/41 [============================>.] - ETA: 1s - loss: 0.2387
```



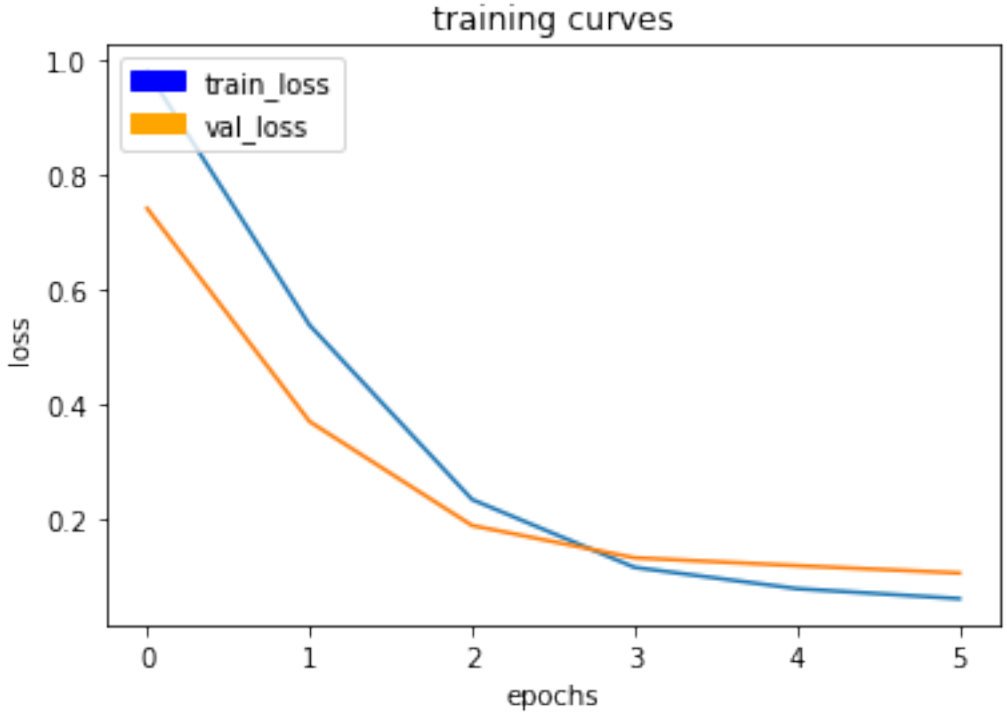
```
41/41 [==============================] - 57s - loss: 0.2366 - val_loss: 0.1898
Epoch 4/200
40/41 [============================>.] - ETA: 1s - loss: 0.1181
```



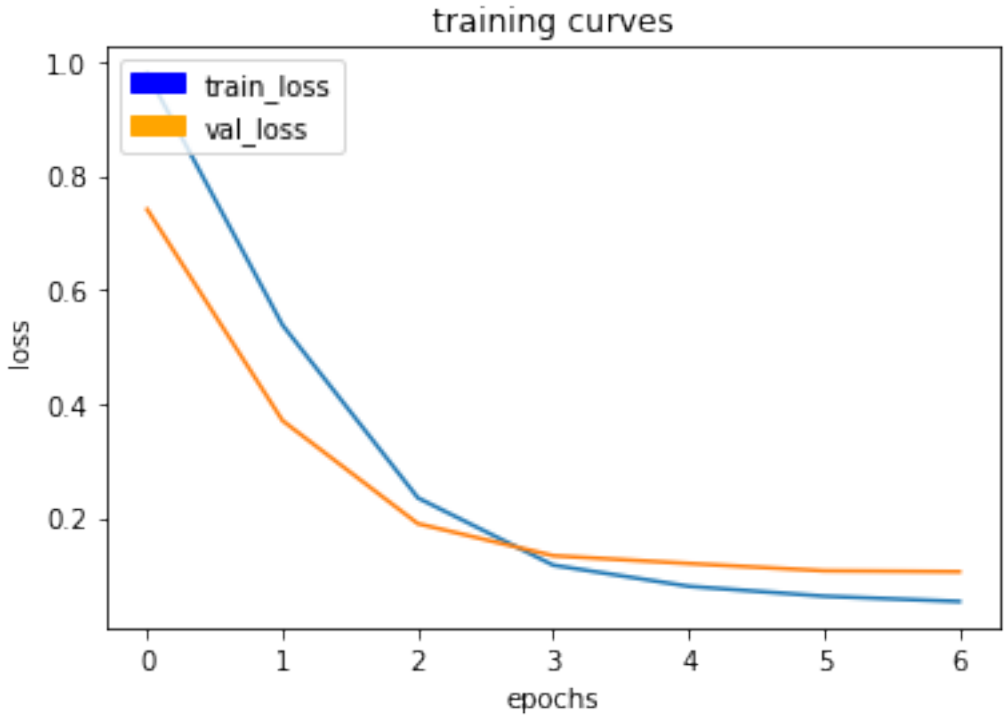

```
41/41 [==============================] - 57s - loss: 0.1174 - val_loss: 0.1336
Epoch 5/200
40/41 [============================>.] - ETA: 1s - loss: 0.0803
```



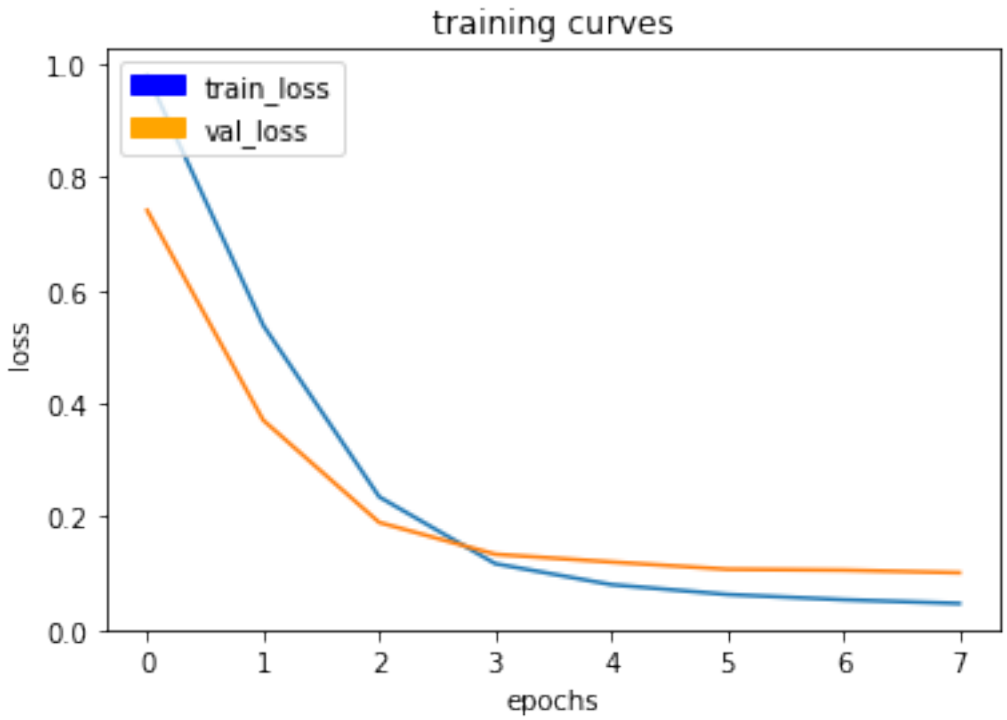

```
41/41 [==============================] - 58s - loss: 0.0802 - val_loss: 0.1200
Epoch 6/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0627
```



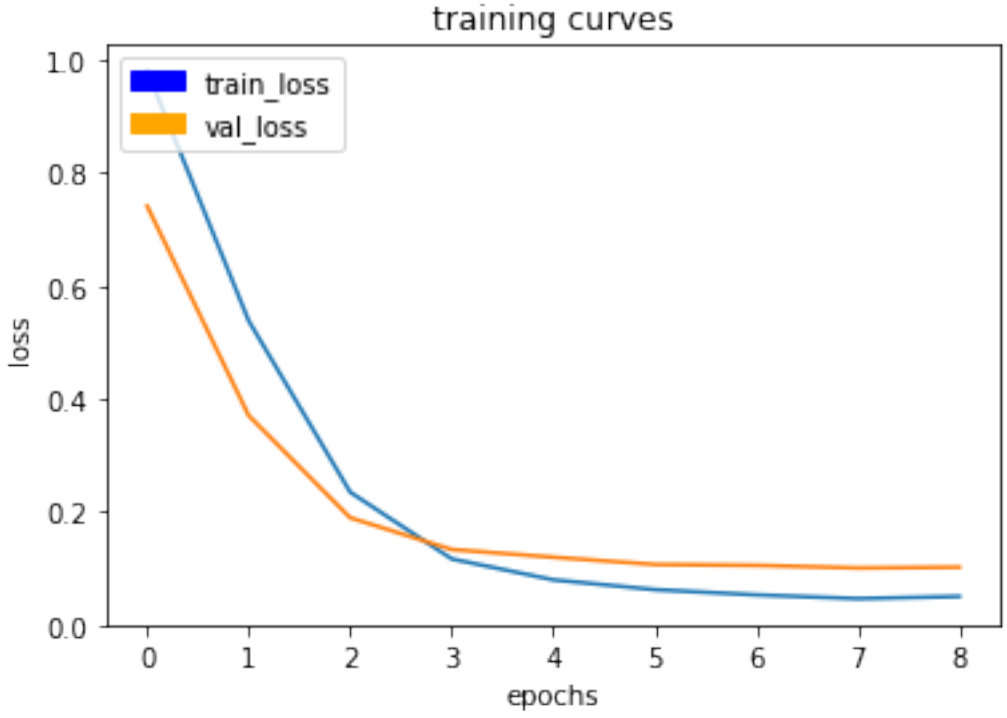
```
41/41 [==============================] - 58s - loss: 0.0627 - val_loss: 0.1072
Epoch 7/200
40/41 [============================>.] - ETA: 1s - loss: 0.0532
```



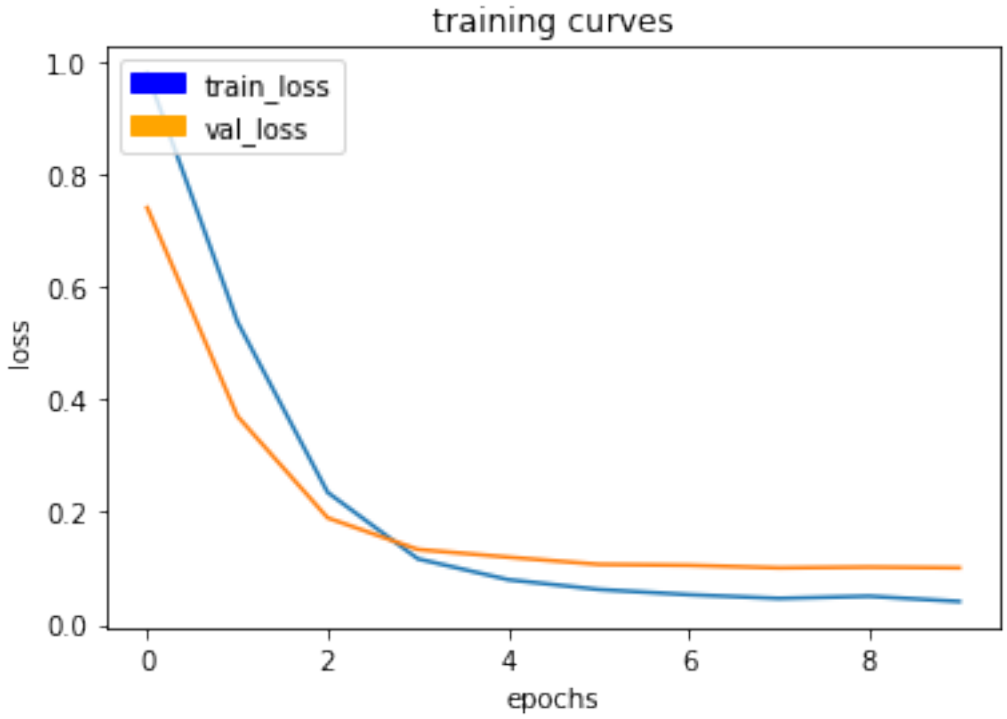

```
41/41 [==============================] - 57s - loss: 0.0533 - val_loss: 0.1056
Epoch 8/200
40/41 [============================>.] - ETA: 1s - loss: 0.0469
```



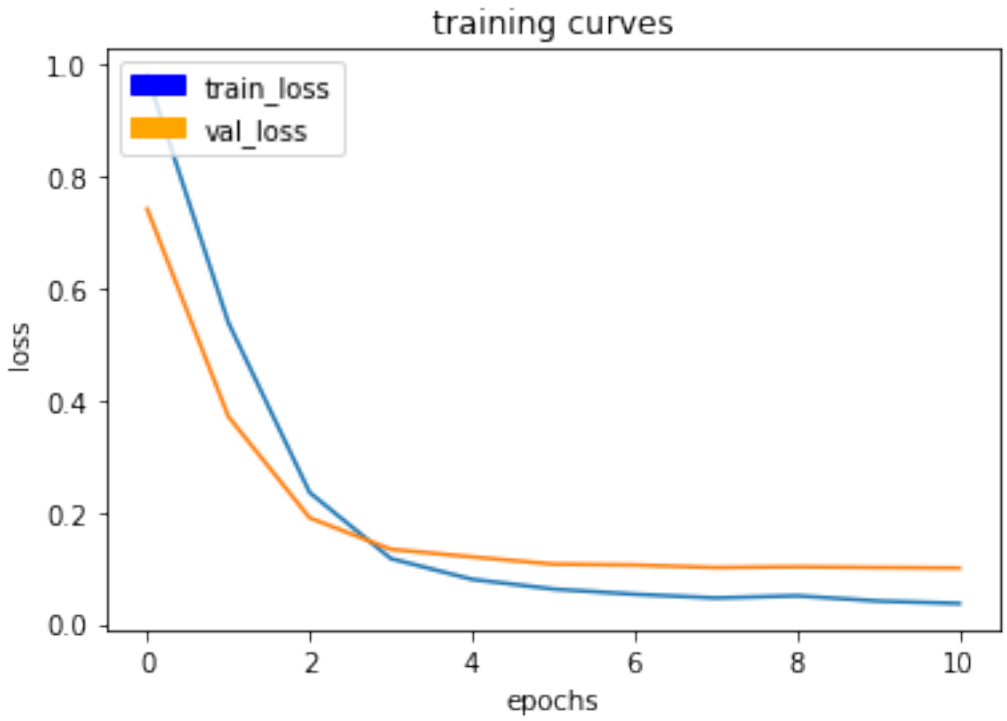

```
41/41 [==============================] - 57s - loss: 0.0467 - val_loss: 0.1010
Epoch 9/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0521
```



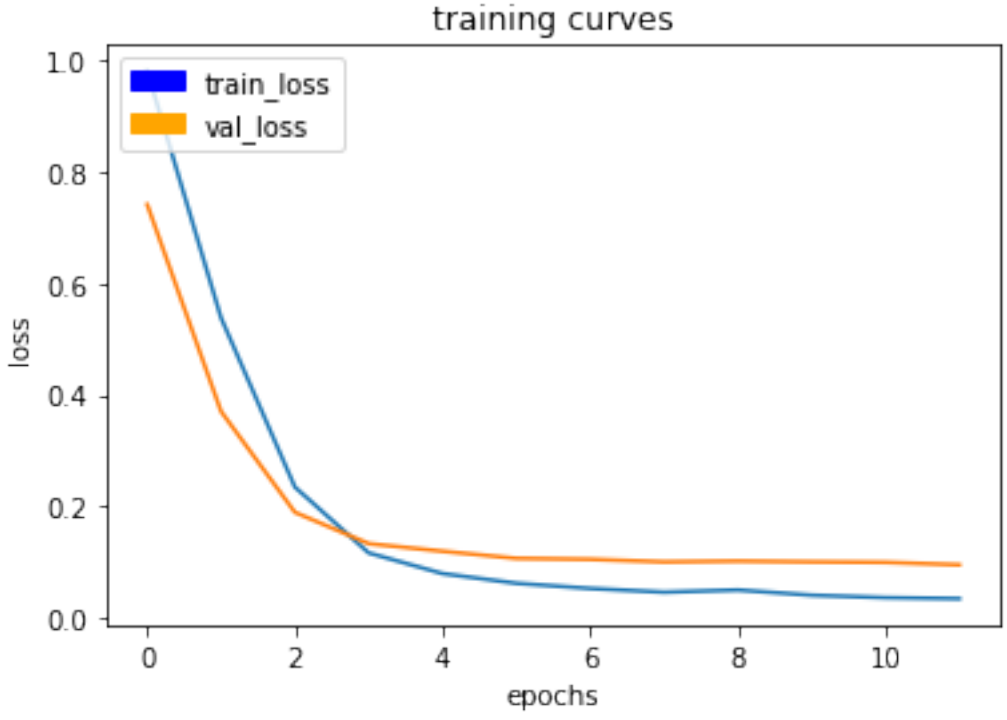
```
41/41 [==============================] - 58s - loss: 0.0519 - val_loss: 0.1023
Epoch 10/200
40/41 [============================>.] - ETA: 1s - loss: 0.0414
```



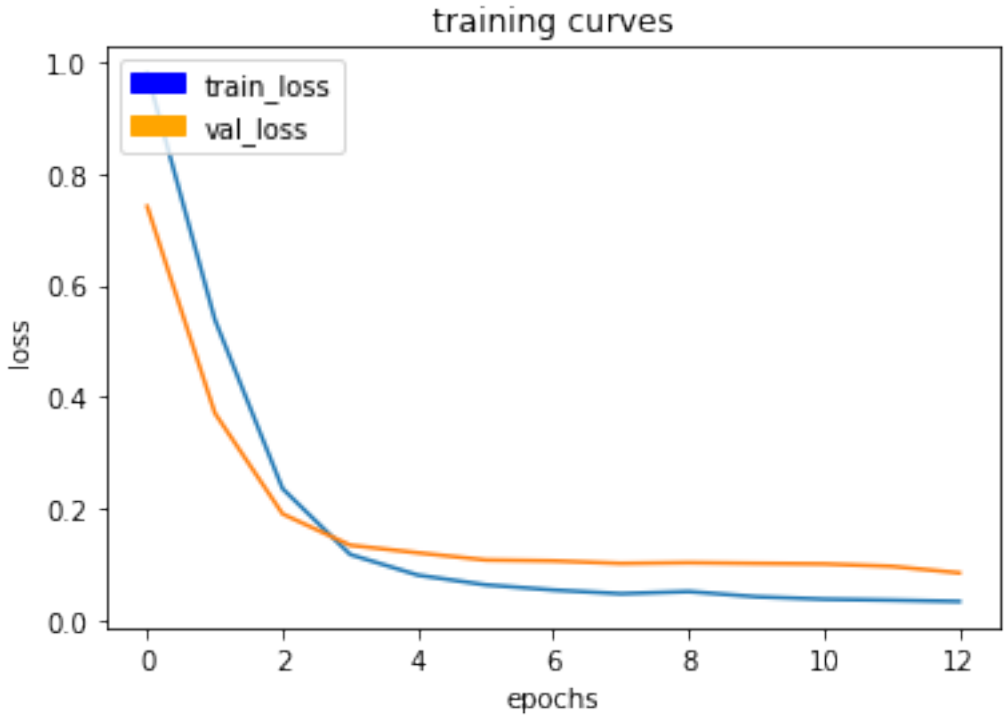

```
41/41 [==============================] - 57s - loss: 0.0412 - val_loss: 0.1011
Epoch 11/200
40/41 [============================>.] - ETA: 1s - loss: 0.0372
```



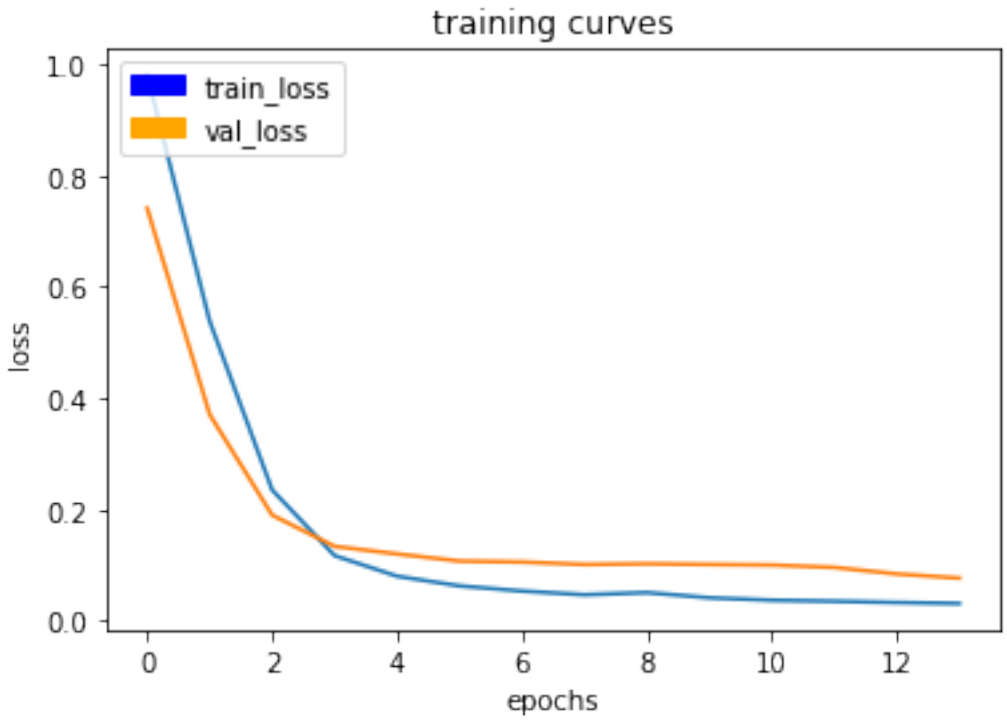

```
41/41 [==============================] - 57s - loss: 0.0370 - val_loss: 0.1001
Epoch 12/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0351
```



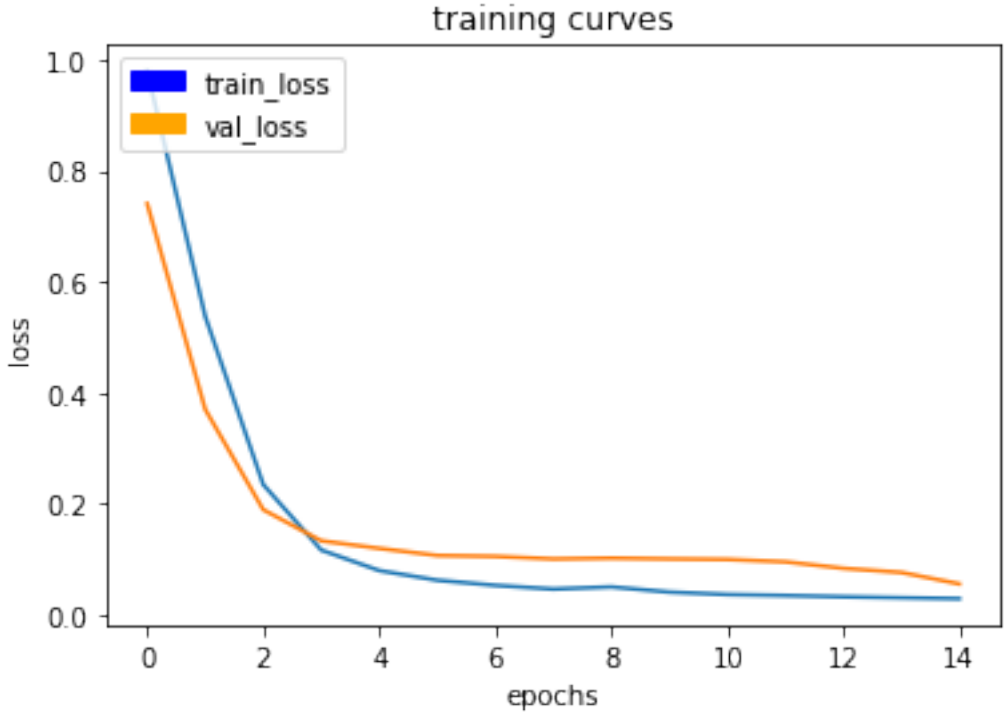
```
41/41 [==============================] - 57s - loss: 0.0350 - val_loss: 0.0958
Epoch 13/200
40/41 [============================>.] - ETA: 1s - loss: 0.0327
```



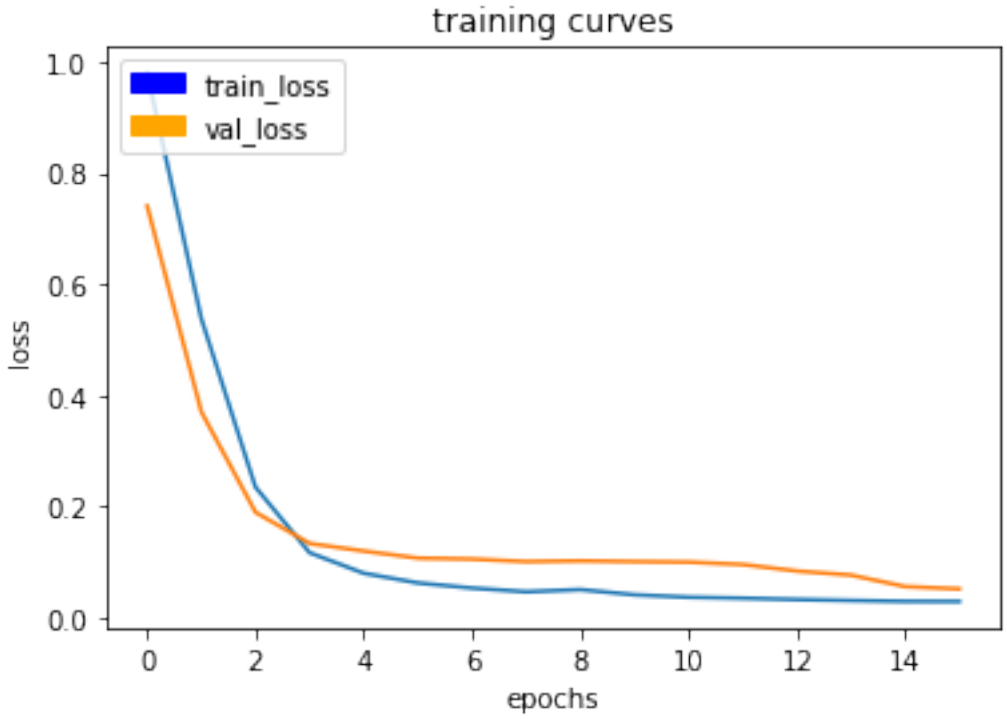

```
41/41 [==============================] - 57s - loss: 0.0328 - val_loss: 0.0841
Epoch 14/200
40/41 [============================>.] - ETA: 1s - loss: 0.0310
```



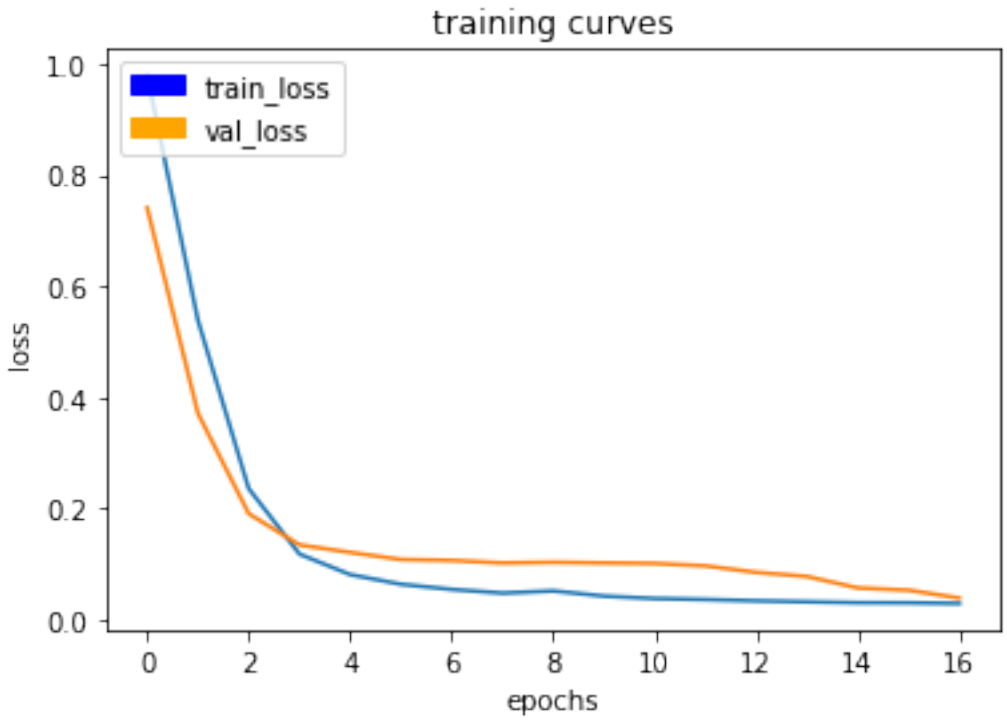

```
41/41 [==============================] - 57s - loss: 0.0310 - val_loss: 0.0766
Epoch 15/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0294
```



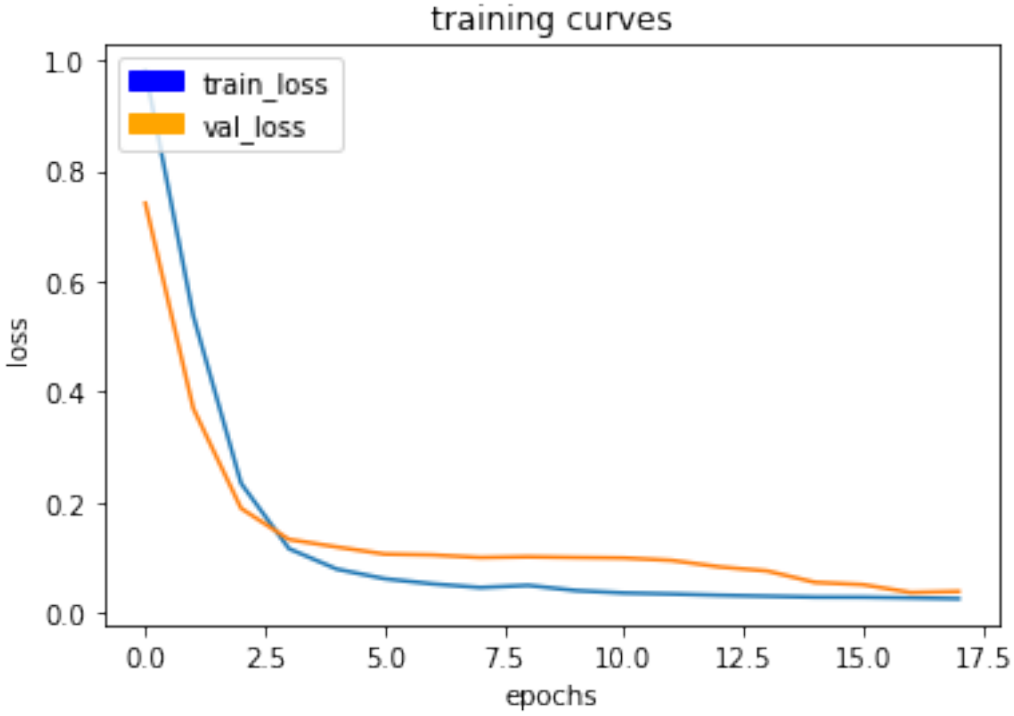
```
41/41 [==============================] - 57s - loss: 0.0295 - val_loss: 0.0560
Epoch 16/200
40/41 [============================>.] - ETA: 1s - loss: 0.0293
```



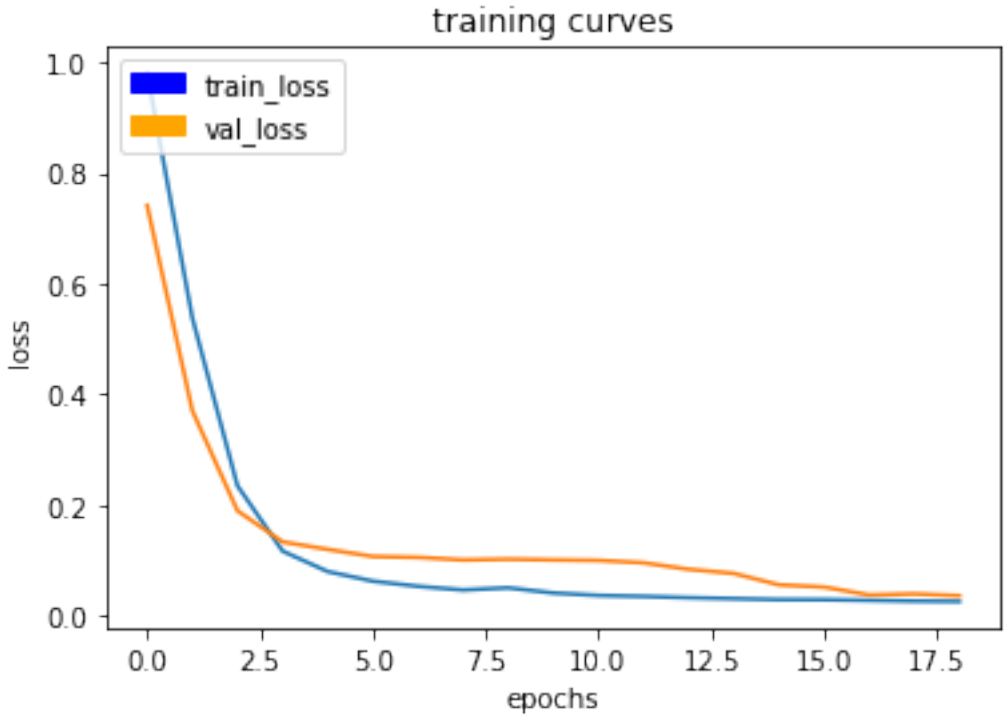

```
41/41 [==============================] - 58s - loss: 0.0294 - val_loss: 0.0520
Epoch 17/200
40/41 [============================>.] - ETA: 1s - loss: 0.0281
```



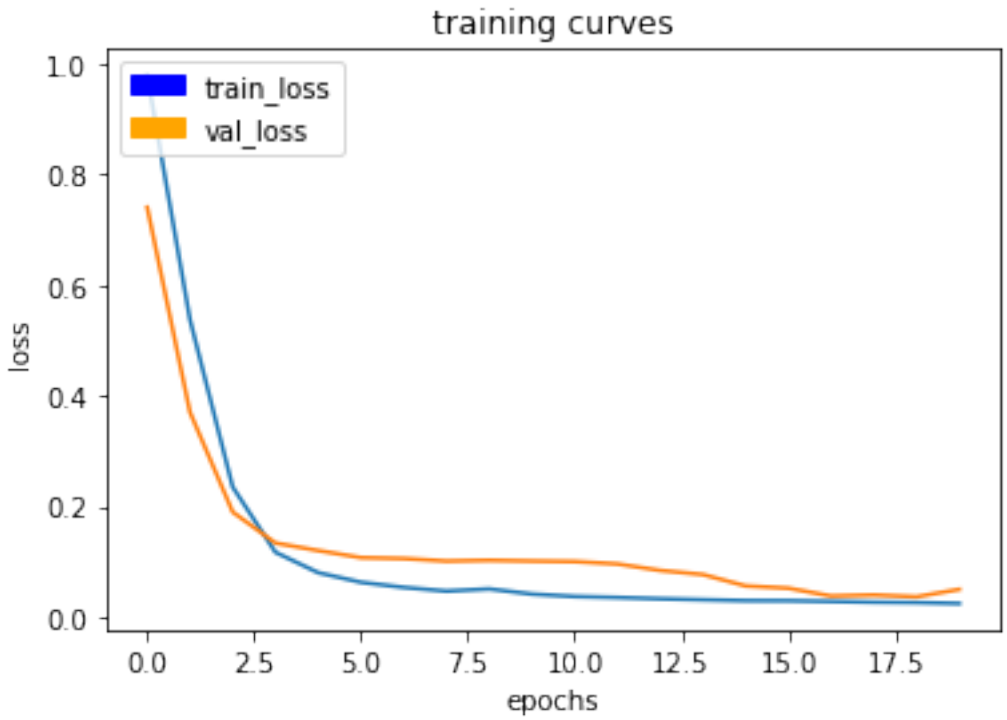

```
41/41 [==============================] - 57s - loss: 0.0280 - val_loss: 0.0378
Epoch 18/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0266
```



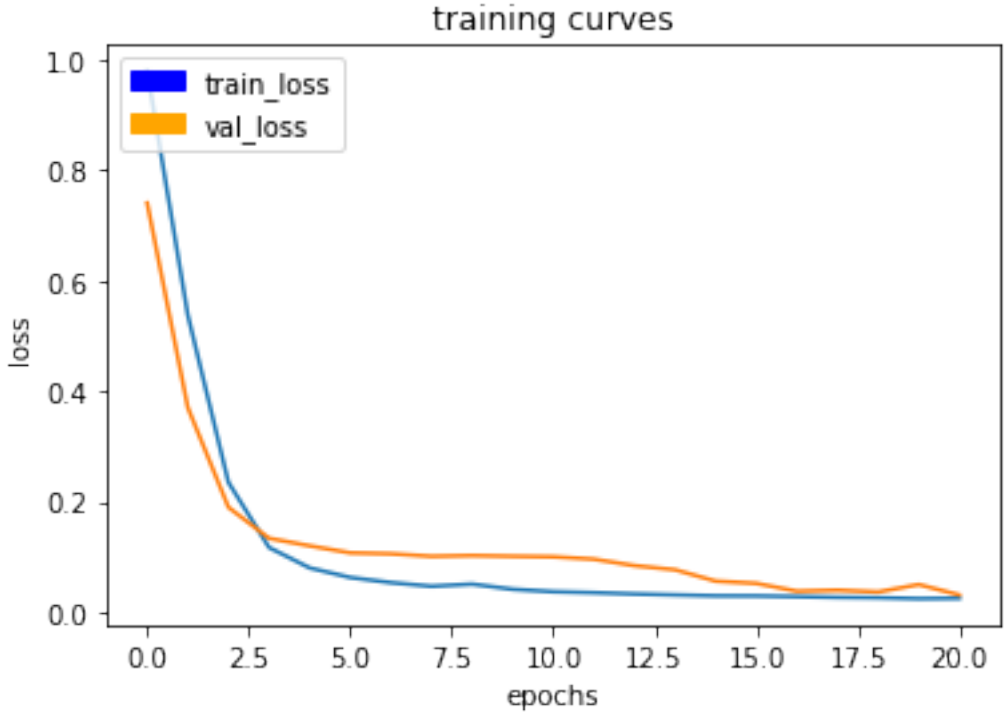
```
41/41 [==============================] - 57s - loss: 0.0266 - val_loss: 0.0396
Epoch 19/200
40/41 [============================>.] - ETA: 1s - loss: 0.0260
```



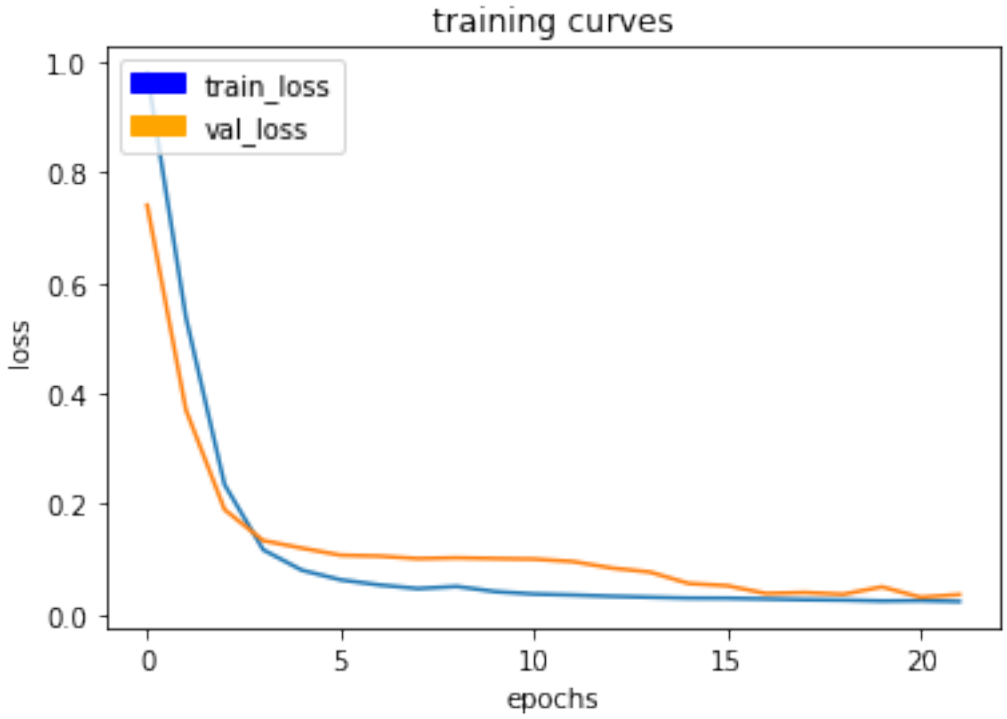

```
41/41 [==============================] - 57s - loss: 0.0259 - val_loss: 0.0364
Epoch 20/200
40/41 [============================>.] - ETA: 1s - loss: 0.0243
```



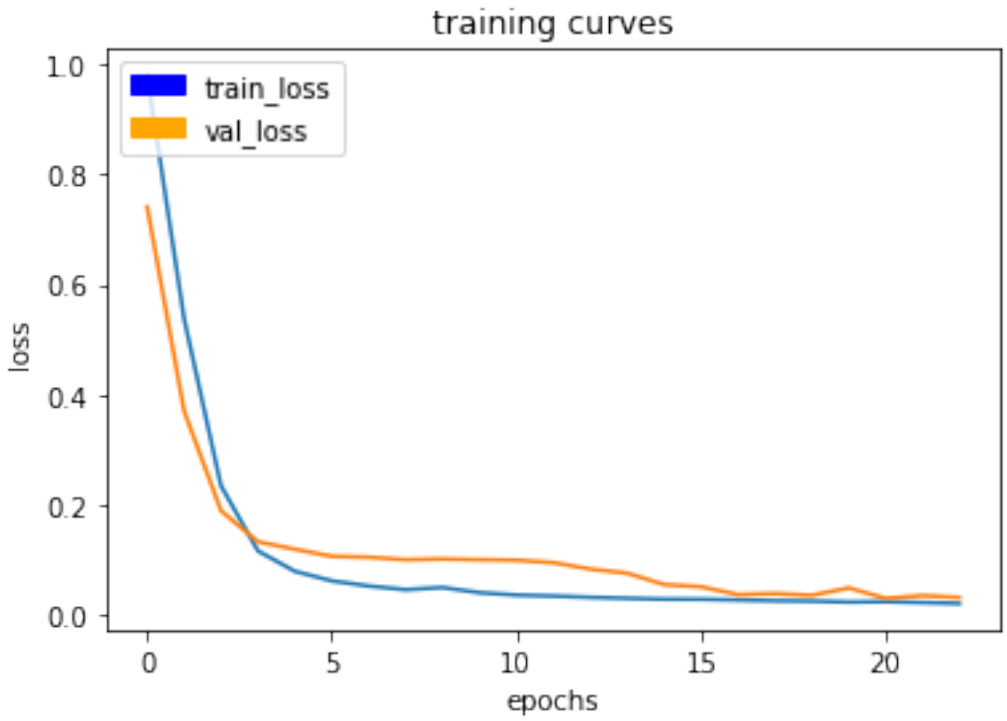

```
41/41 [==============================] - 58s - loss: 0.0243 - val_loss: 0.0498
Epoch 21/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0249
```



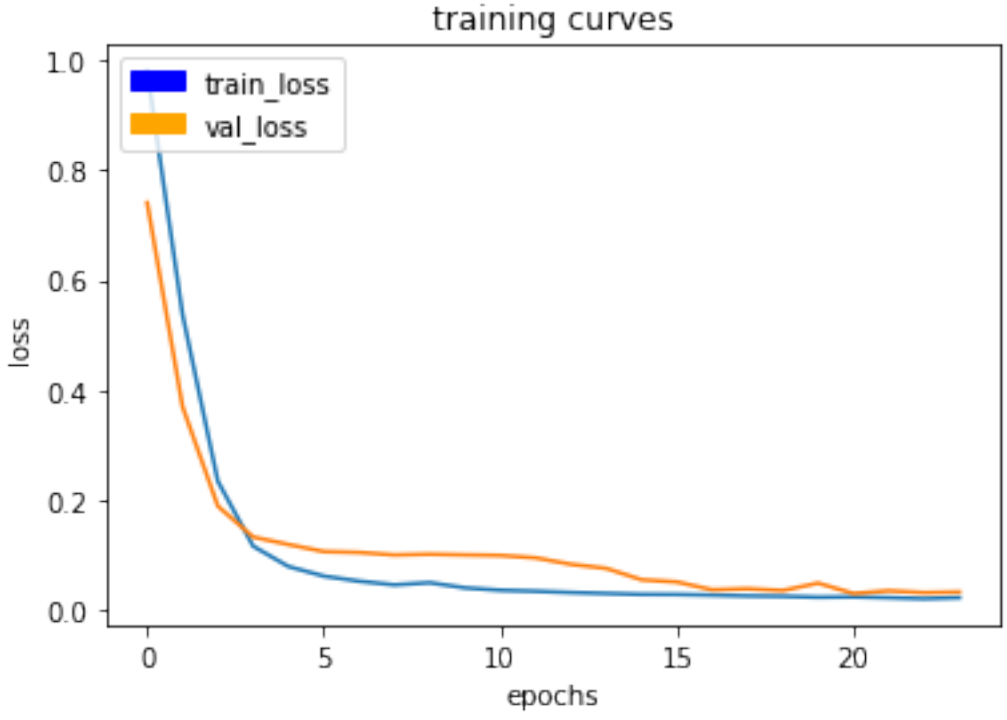
```
41/41 [==============================] - 58s - loss: 0.0250 - val_loss: 0.0310
Epoch 22/200
40/41 [============================>.] - ETA: 1s - loss: 0.0234
```



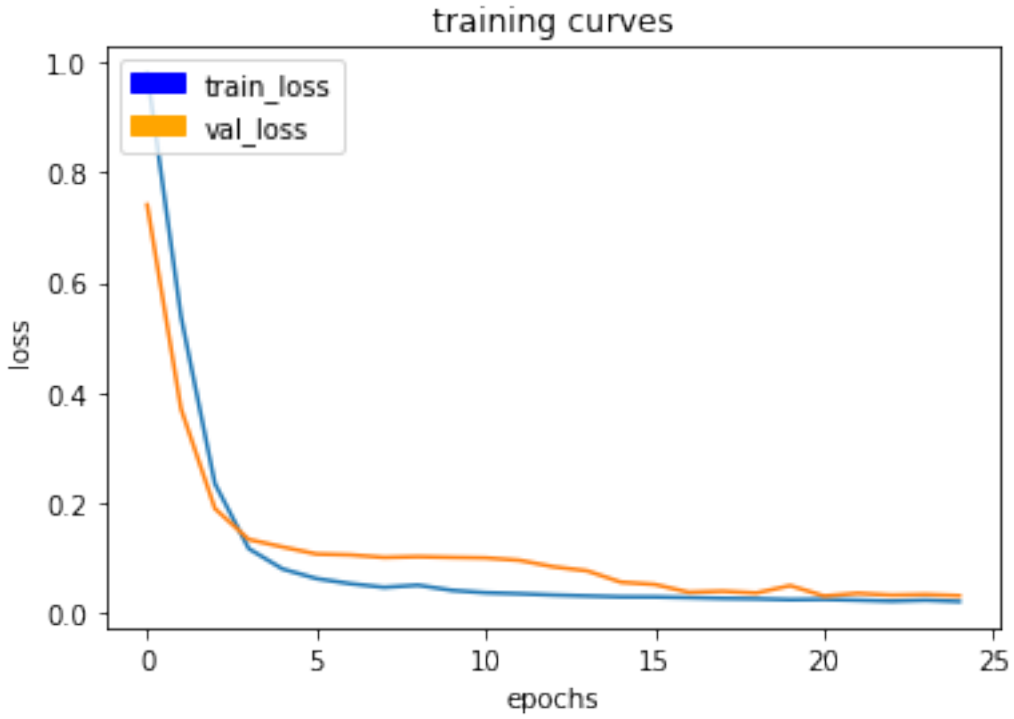

```
41/41 [==============================] - 58s - loss: 0.0234 - val_loss: 0.0359
Epoch 23/200
40/41 [============================>.] - ETA: 1s - loss: 0.0217
```



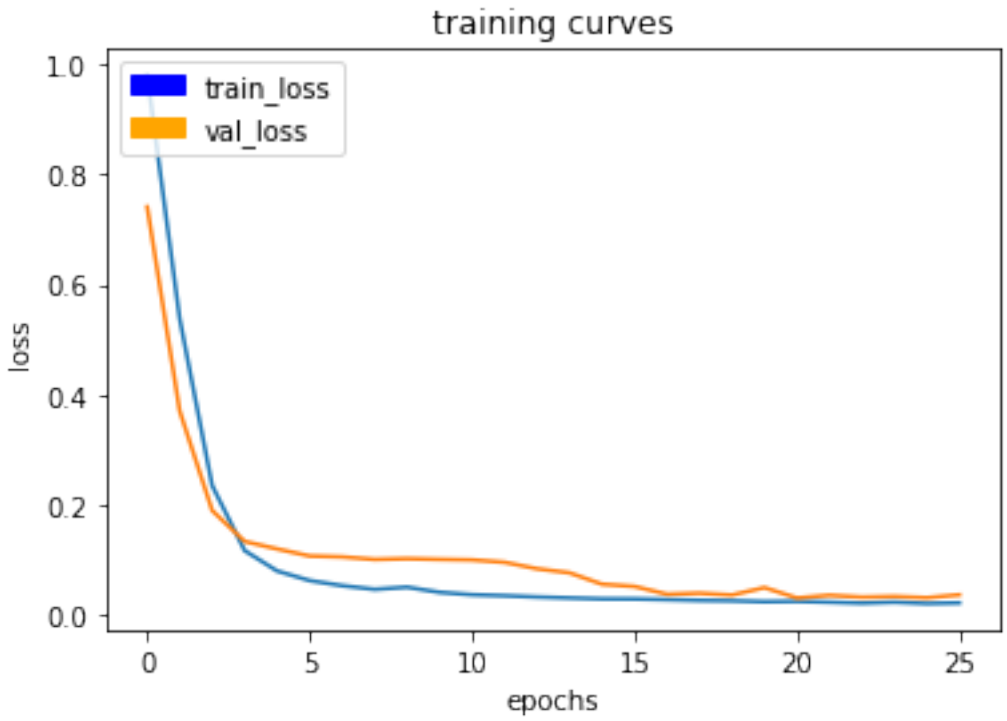

```
41/41 [==============================] - 57s - loss: 0.0217 - val_loss: 0.0326
Epoch 24/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0235
```



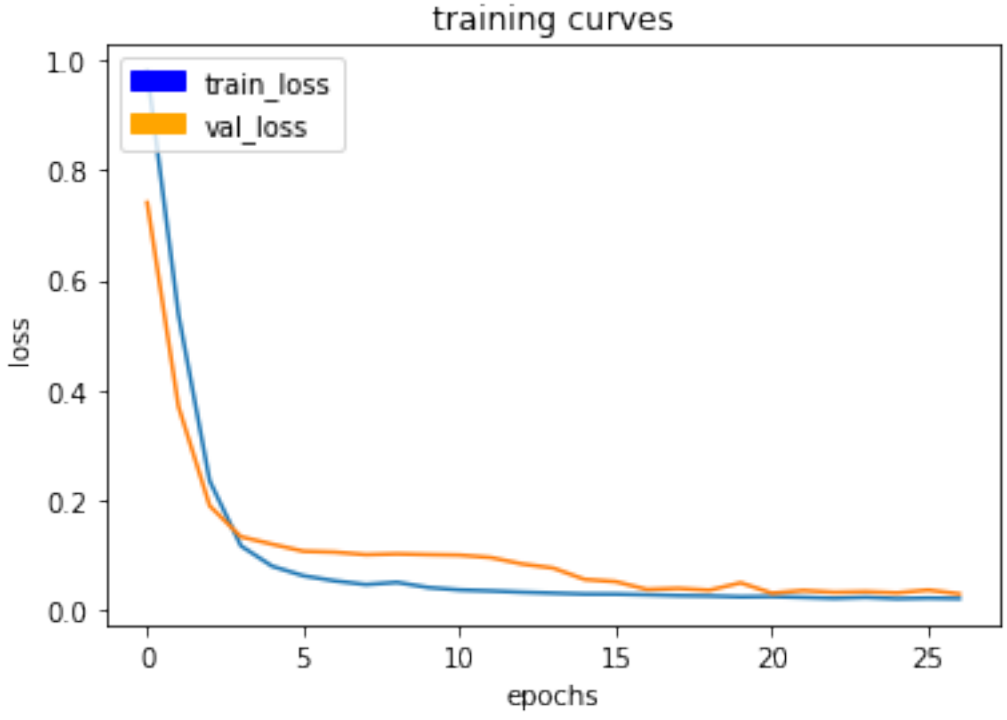
```
41/41 [==============================] - 57s - loss: 0.0234 - val_loss: 0.0337
Epoch 25/200
40/41 [============================>.] - ETA: 1s - loss: 0.0211
```



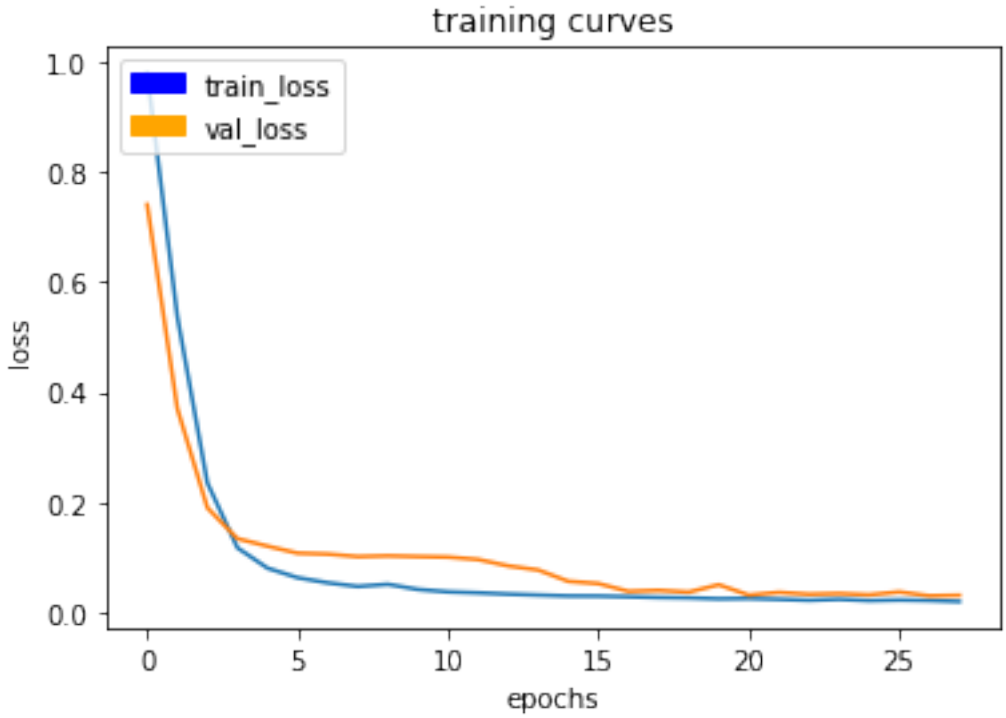

```
41/41 [==============================] - 57s - loss: 0.0210 - val_loss: 0.0315
Epoch 26/200
40/41 [============================>.] - ETA: 1s - loss: 0.0224
```



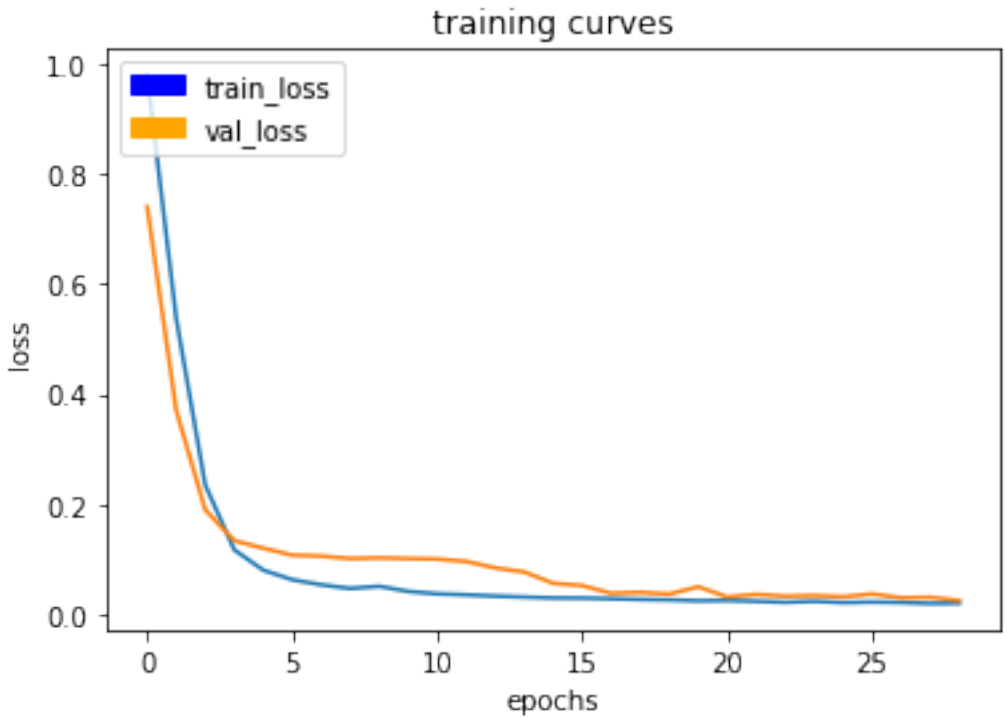

```
41/41 [==============================] - 58s - loss: 0.0224 - val_loss: 0.0367
Epoch 27/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0213
```



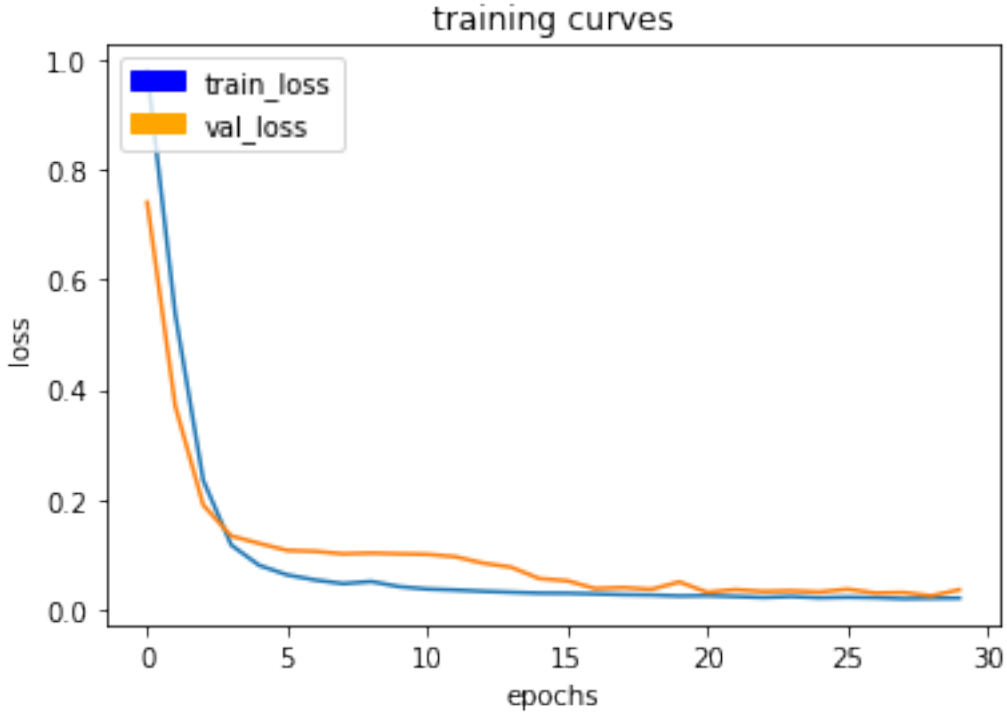
```
41/41 [==============================] - 57s - loss: 0.0213 - val_loss: 0.0297
Epoch 28/200
40/41 [============================>.] - ETA: 1s - loss: 0.0195
```



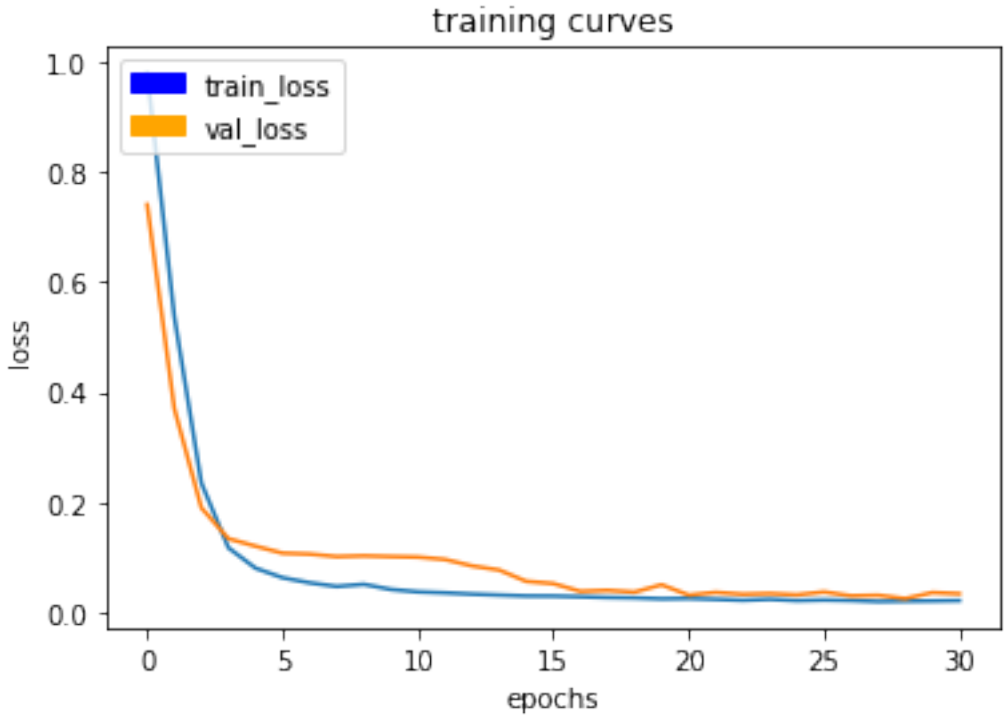

```
41/41 [==============================] - 57s - loss: 0.0194 - val_loss: 0.0307
Epoch 29/200
40/41 [============================>.] - ETA: 1s - loss: 0.0200
```



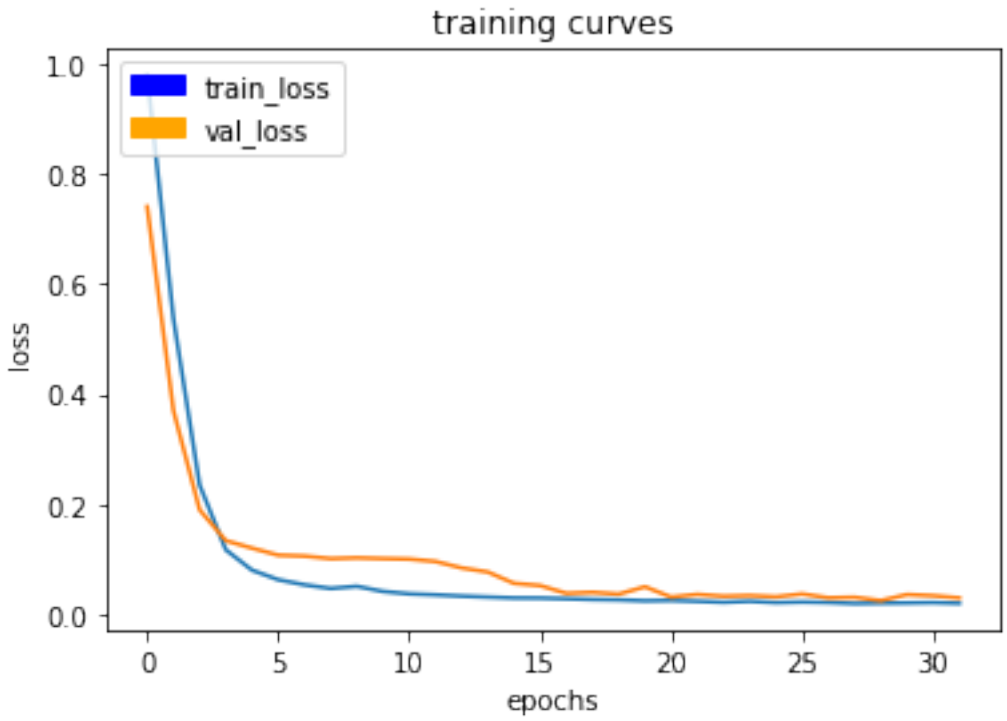

```
41/41 [==============================] - 57s - loss: 0.0200 - val_loss: 0.0246
Epoch 30/200
40/41 [============================>.] - ETA: 1s - loss: 0.0204
```



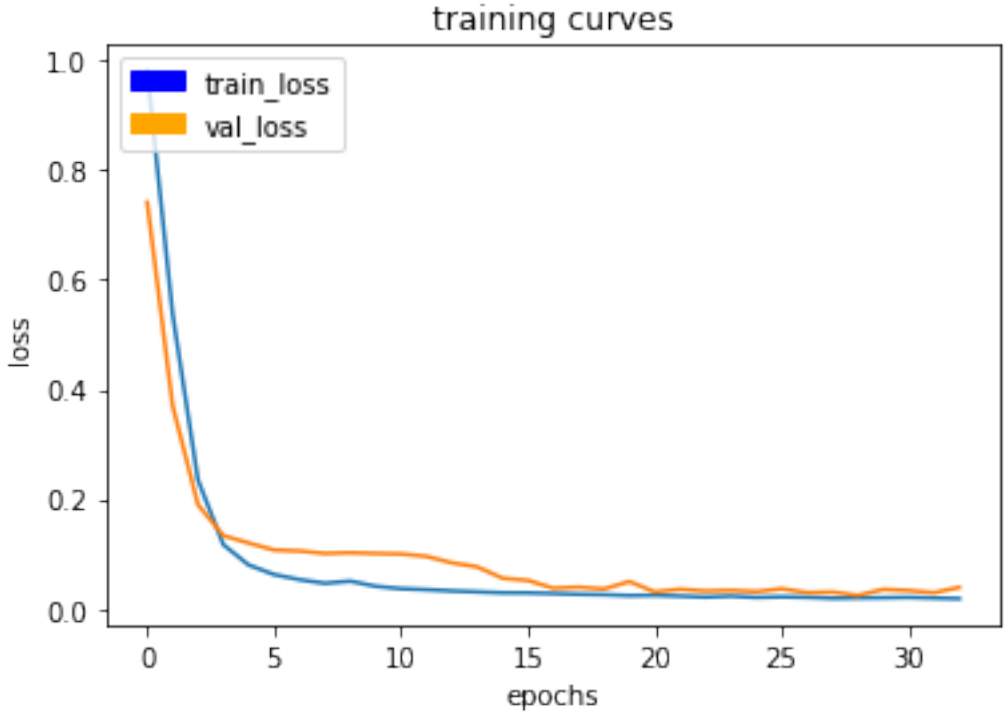
```
41/41 [==============================] - 57s - loss: 0.0204 - val_loss: 0.0356
Epoch 31/200
40/41 [============================>.] - ETA: 1s - loss: 0.0211
```



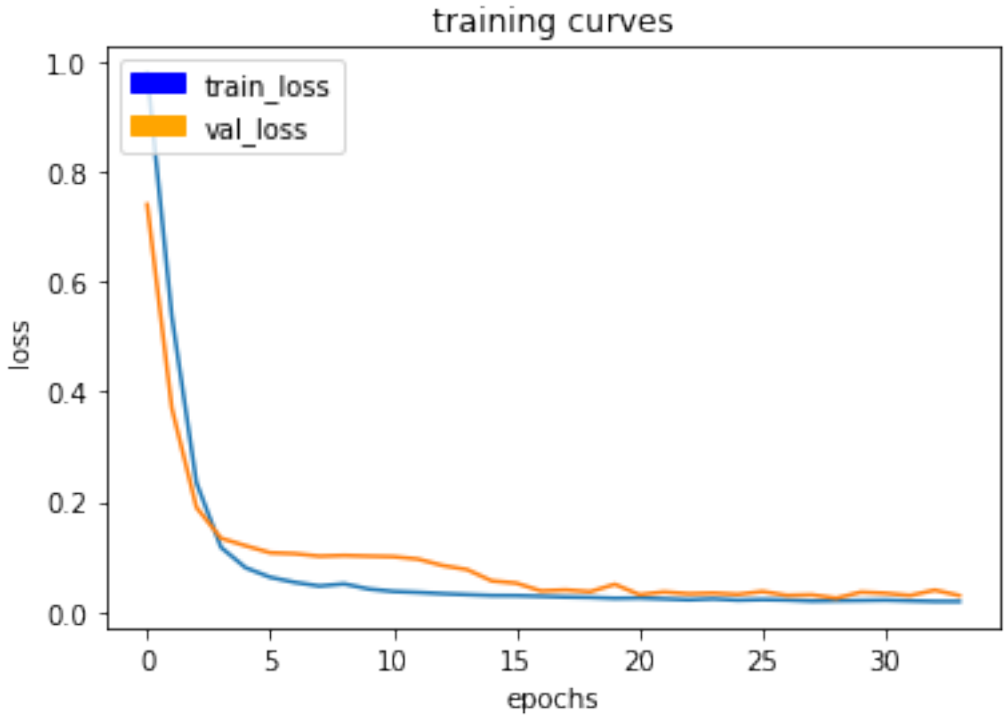

```
41/41 [==============================] - 57s - loss: 0.0211 - val_loss: 0.0335
Epoch 32/200
40/41 [============================>.] - ETA: 1s - loss: 0.0199
```



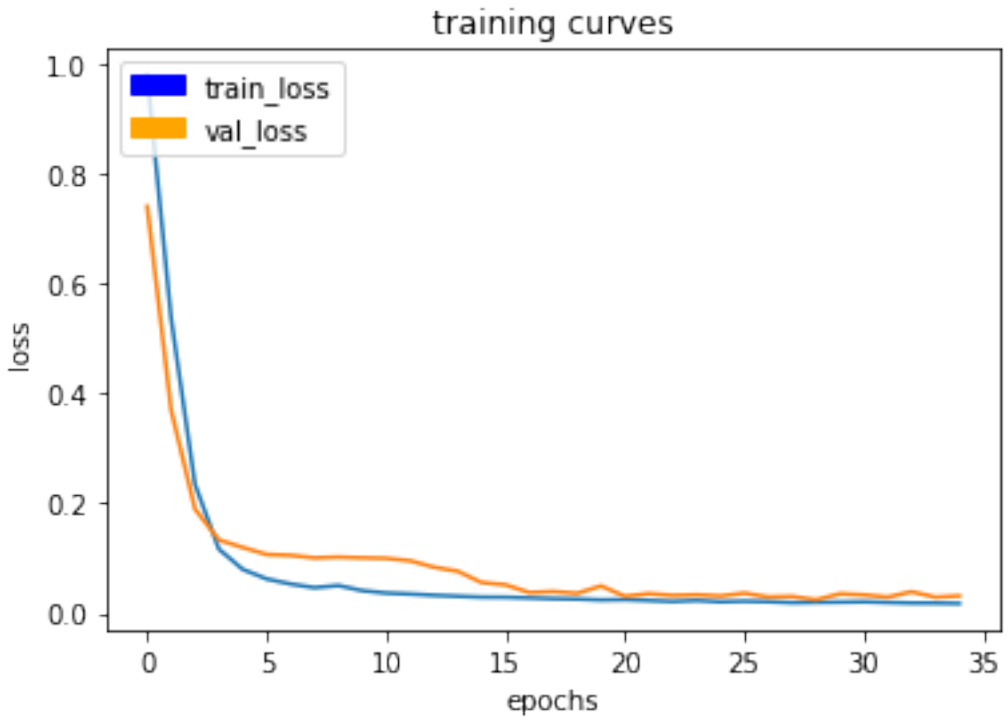

```
41/41 [==============================] - 57s - loss: 0.0198 - val_loss: 0.0295
Epoch 33/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0187
```



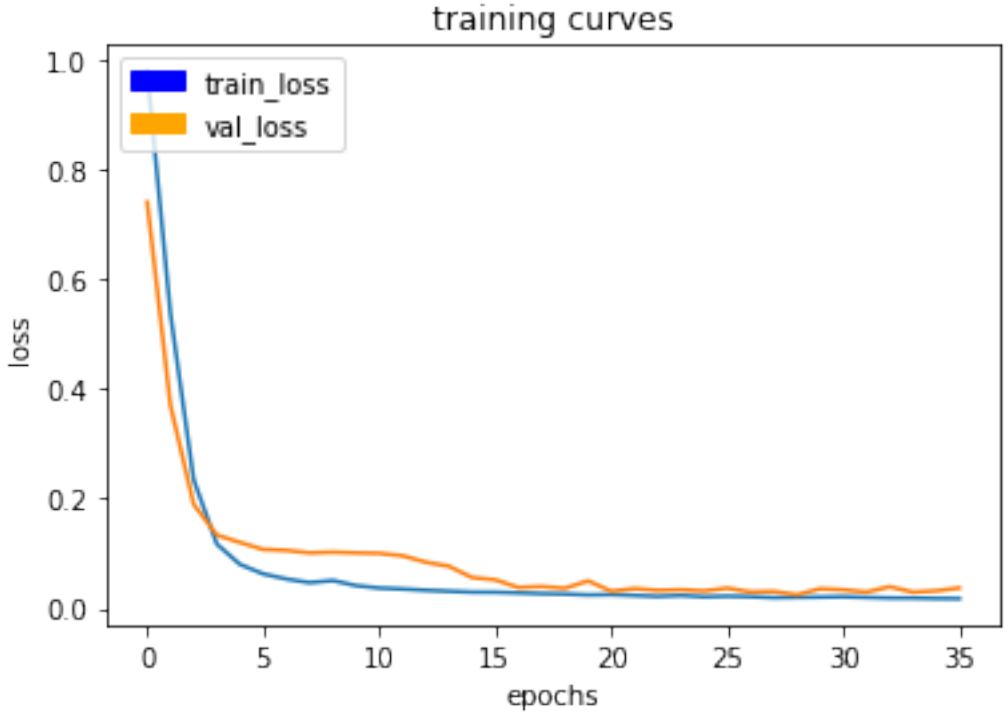
```
41/41 [==============================] - 57s - loss: 0.0187 - val_loss: 0.0393
Epoch 34/200
40/41 [============================>.] - ETA: 1s - loss: 0.0185
```



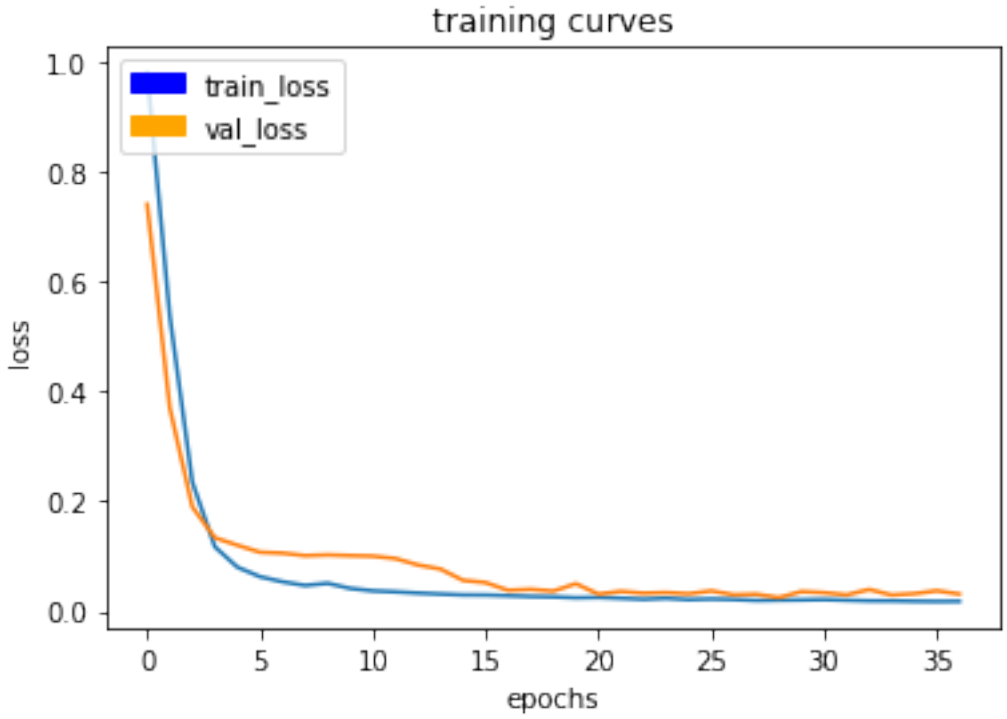

```
41/41 [==============================] - 58s - loss: 0.0186 - val_loss: 0.0294
Epoch 35/200
40/41 [============================>.] - ETA: 1s - loss: 0.0179
```



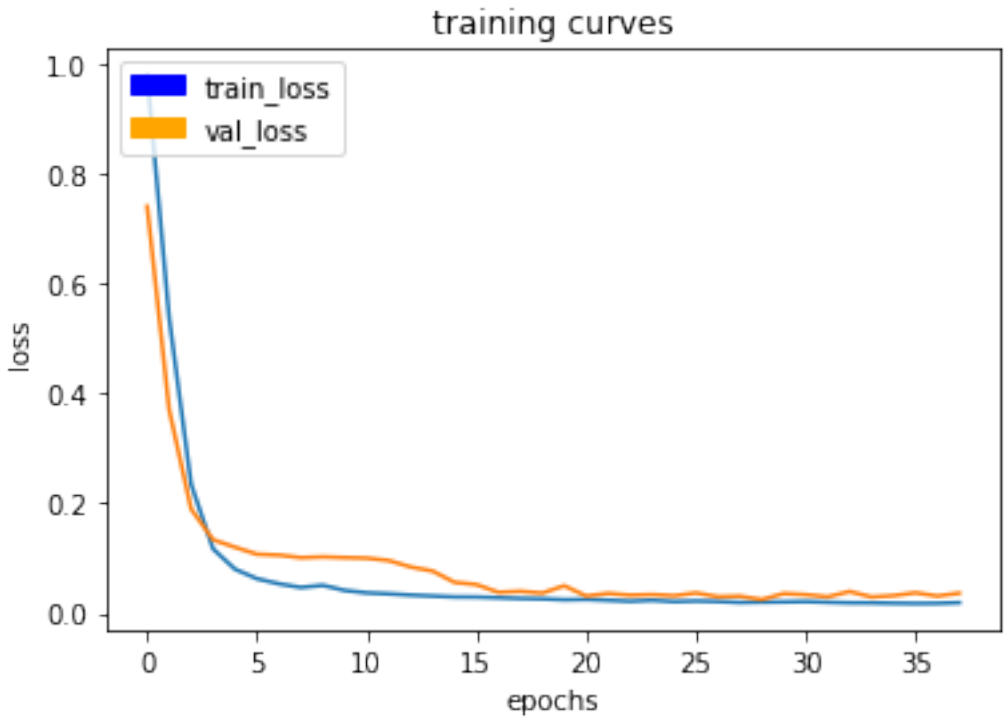

```
41/41 [==============================] - 57s - loss: 0.0179 - val_loss: 0.0317
Epoch 36/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0175
```



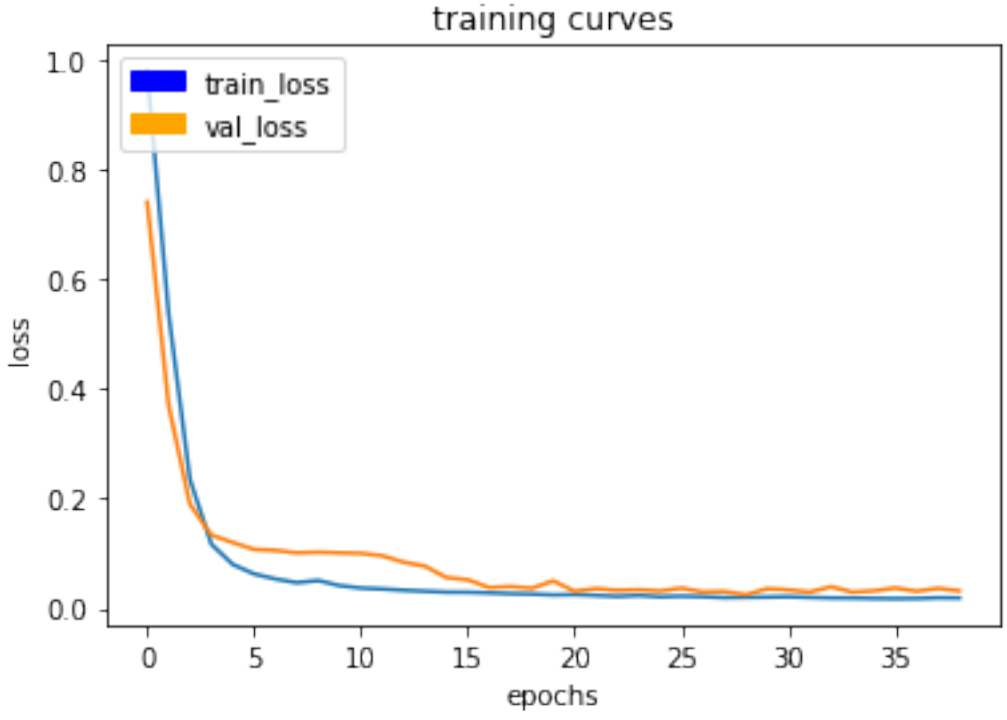
```
41/41 [==============================] - 57s - loss: 0.0175 - val_loss: 0.0370
Epoch 37/200
40/41 [============================>.] - ETA: 1s - loss: 0.0176
```



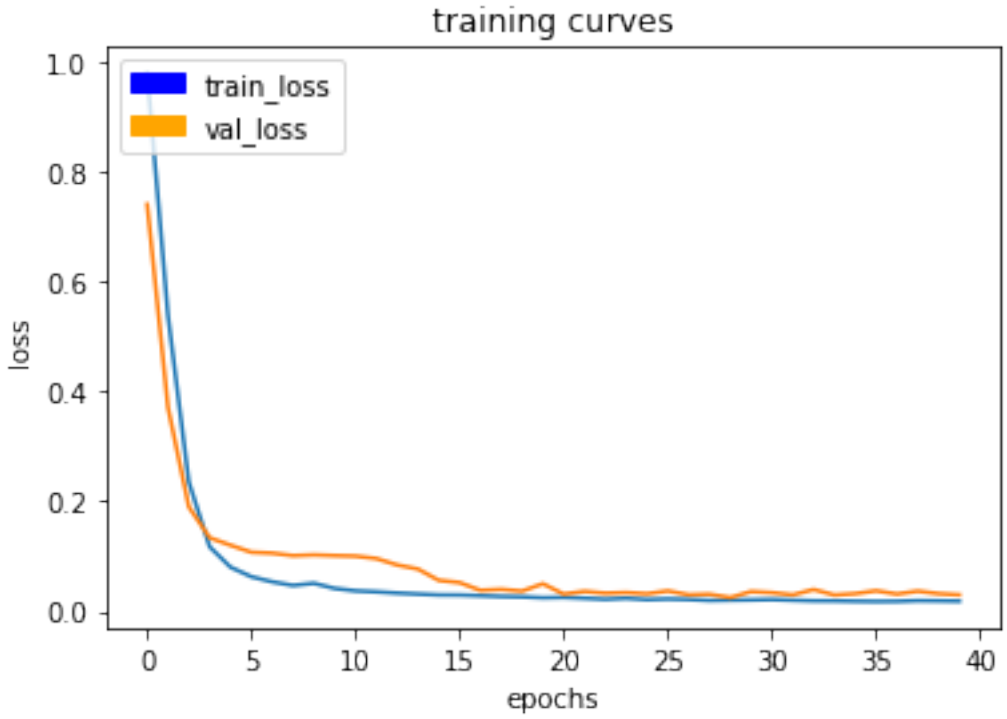

```
41/41 [==============================] - 57s - loss: 0.0176 - val_loss: 0.0310
Epoch 38/200
40/41 [============================>.] - ETA: 1s - loss: 0.0189
```



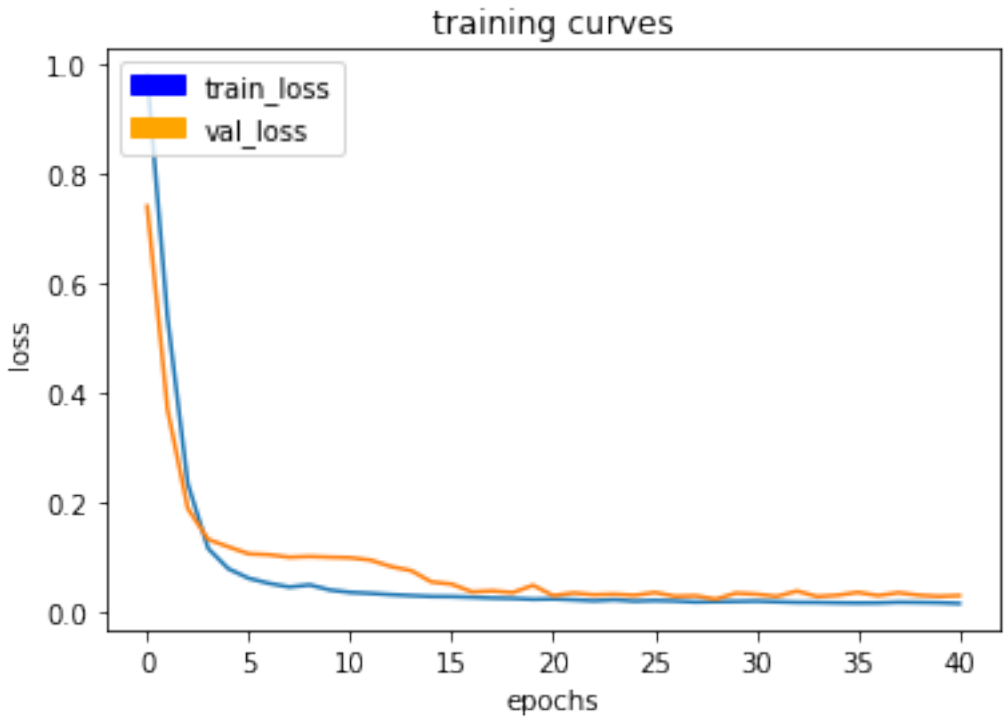

```
41/41 [==============================] - 57s - loss: 0.0190 - val_loss: 0.0363
Epoch 39/200
40/41 [============================>.] - ETA: 1s - loss: 0.0188
```



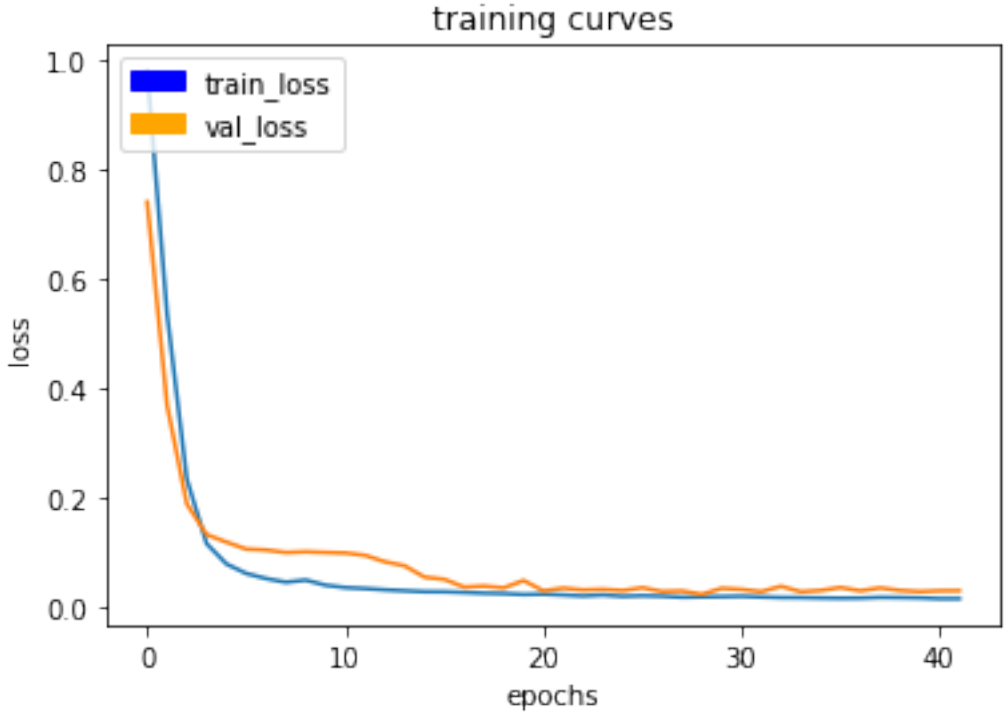
```
41/41 [==============================] - 57s - loss: 0.0187 - val_loss: 0.0318
Epoch 40/200
40/41 [============================>.] - ETA: 1s - loss: 0.0180
```



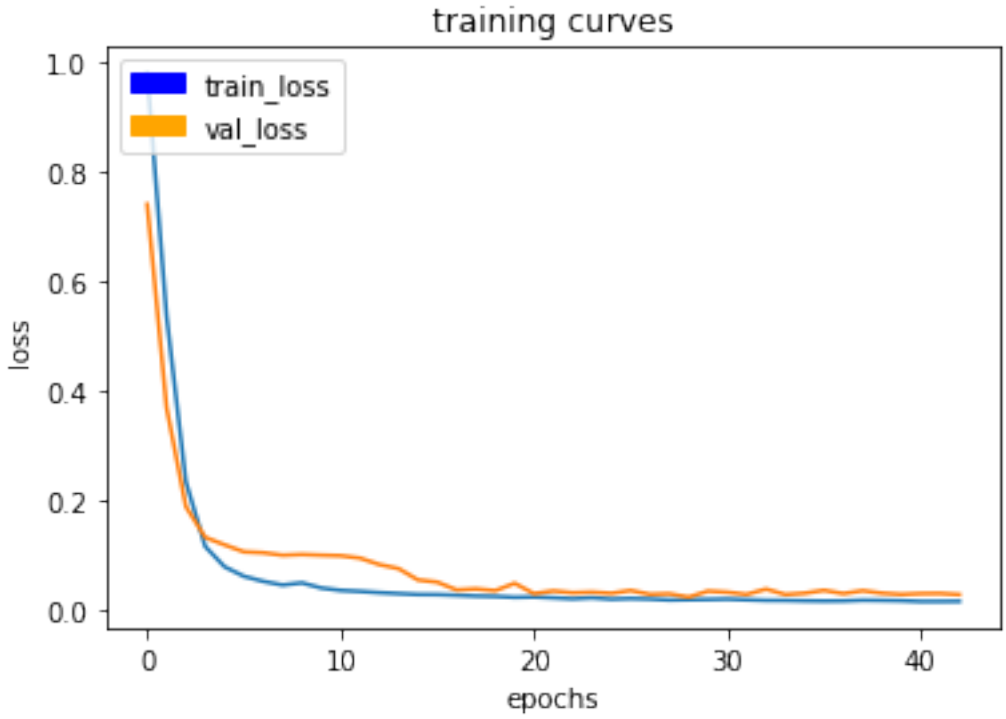

```
41/41 [==============================] - 57s - loss: 0.0180 - val_loss: 0.0296
Epoch 41/200
40/41 [============================>.] - ETA: 1s - loss: 0.0167
```



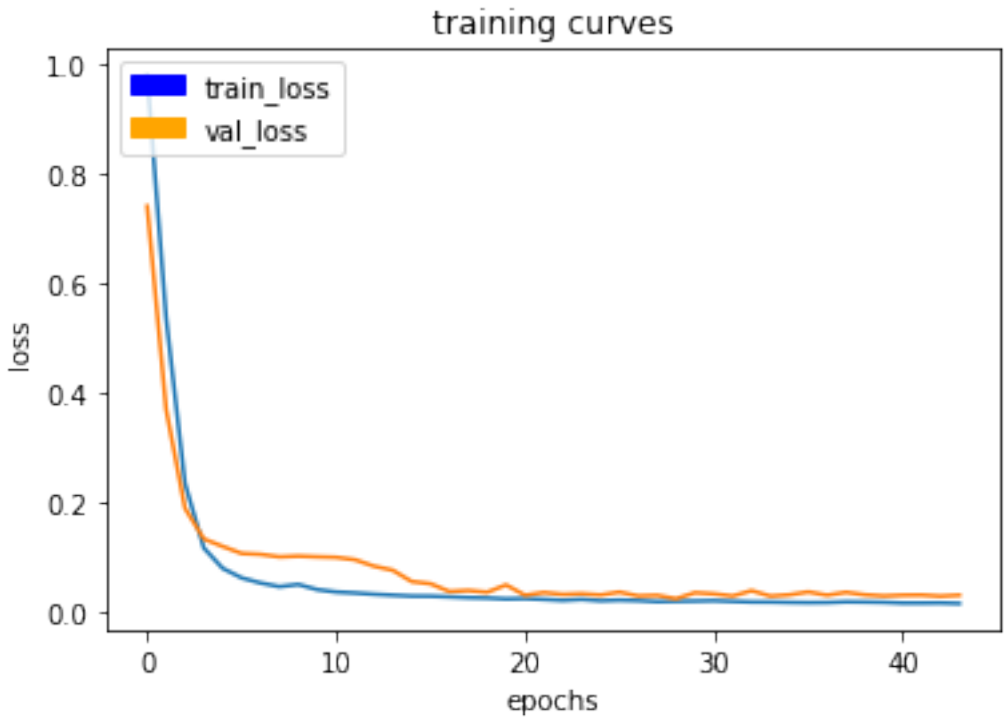

```
41/41 [==============================] - 57s - loss: 0.0167 - val_loss: 0.0310
Epoch 42/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0167
```



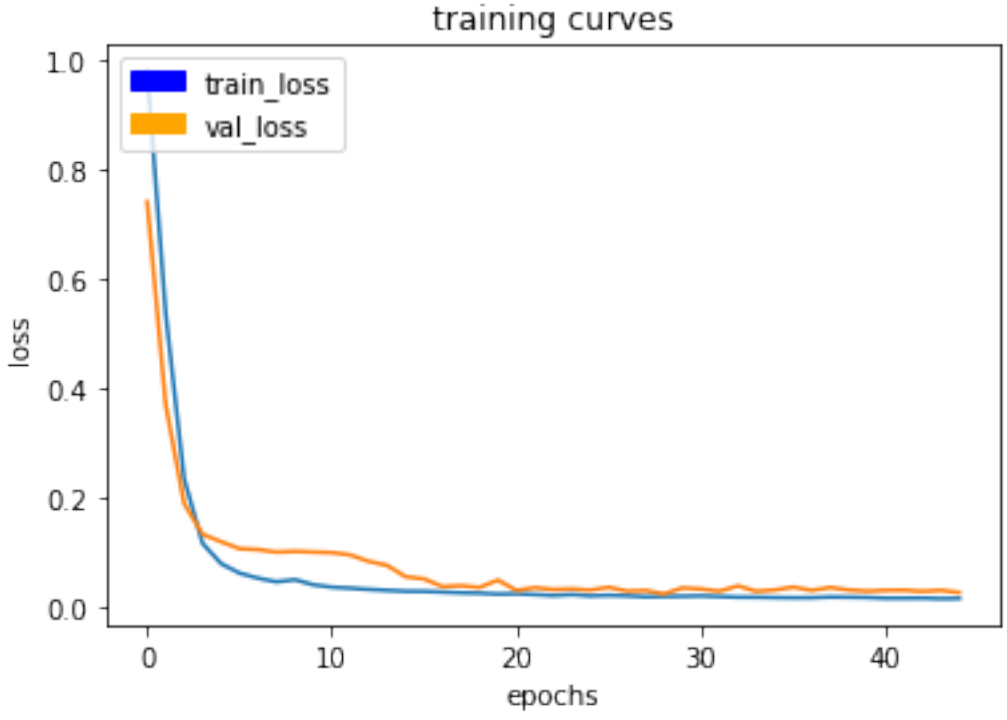
```
41/41 [==============================] - 57s - loss: 0.0167 - val_loss: 0.0313
Epoch 43/200
40/41 [============================>.] - ETA: 1s - loss: 0.0169
```



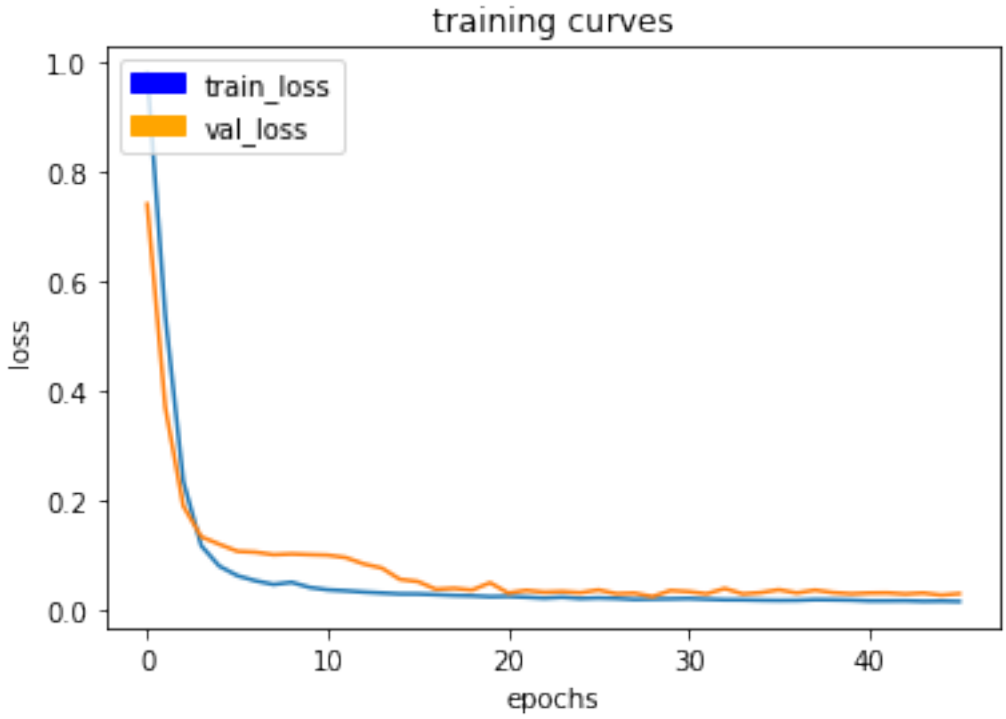

```
41/41 [==============================] - 58s - loss: 0.0169 - val_loss: 0.0293
Epoch 44/200
40/41 [============================>.] - ETA: 1s - loss: 0.0159
```



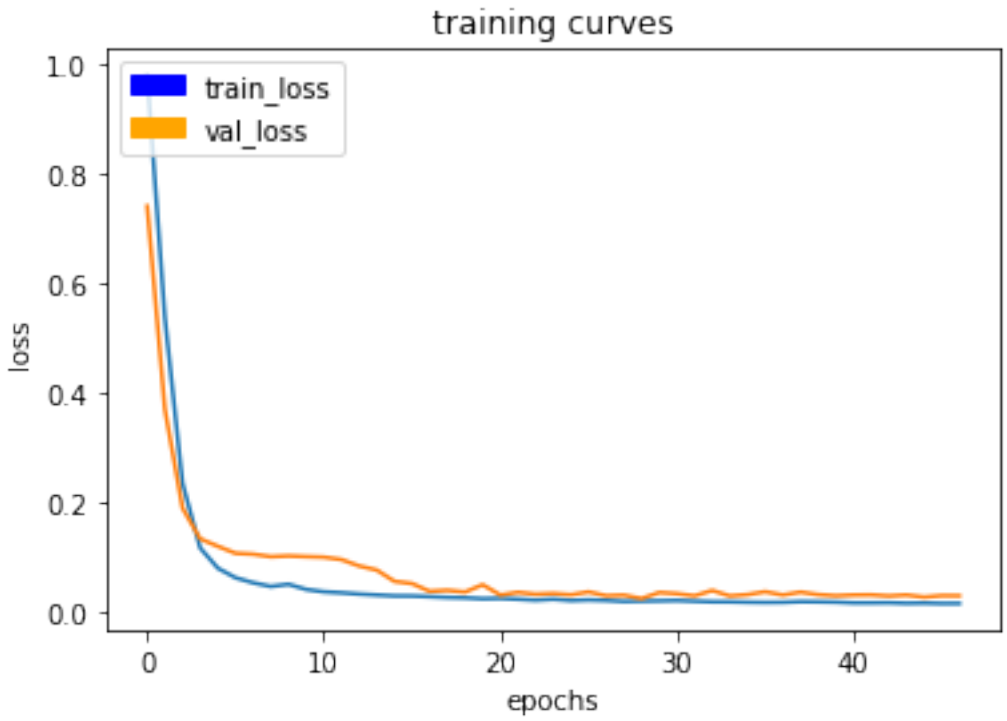

```
41/41 [==============================] - 59s - loss: 0.0159 - val_loss: 0.0310
Epoch 45/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0164
```



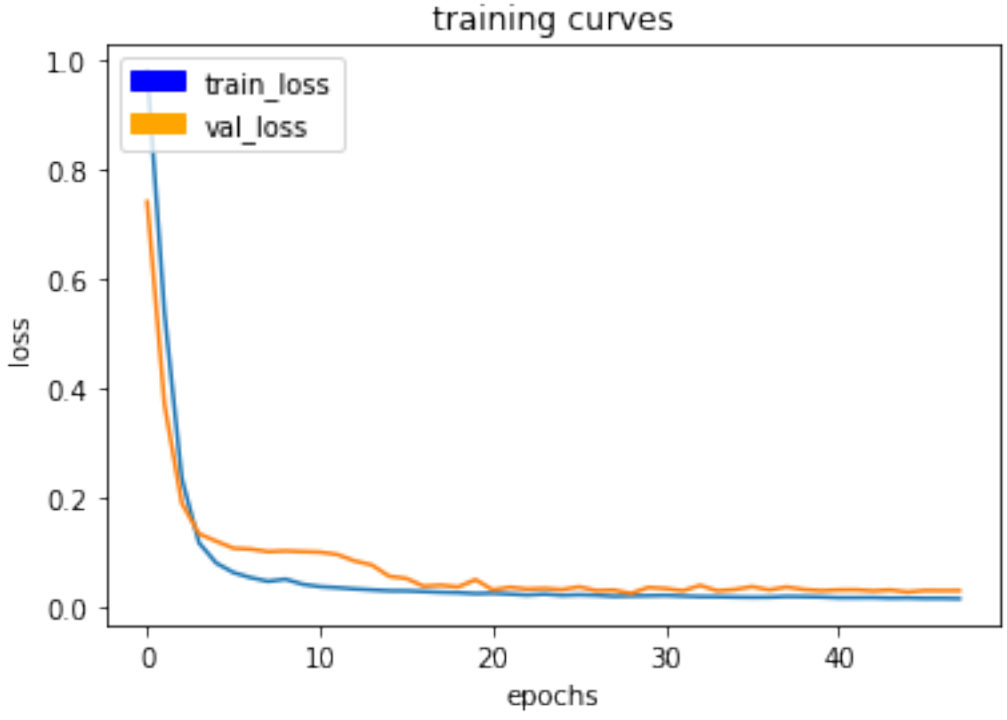
```
41/41 [==============================] - 57s - loss: 0.0163 - val_loss: 0.0272
Epoch 46/200
40/41 [============================>.] - ETA: 1s - loss: 0.0156
```



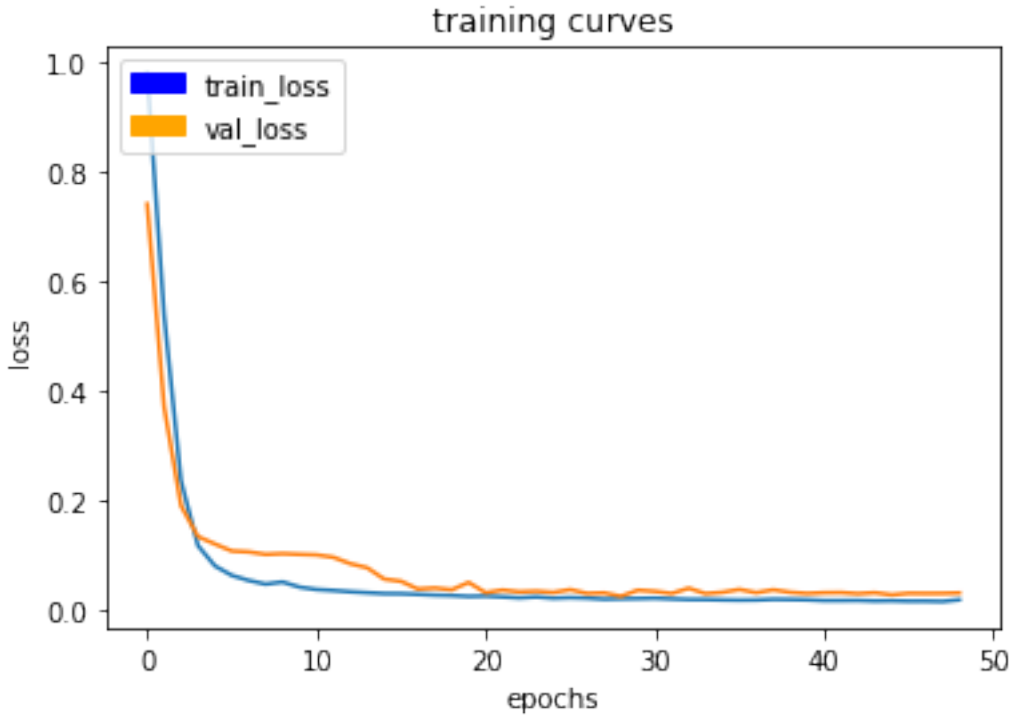

```
41/41 [==============================] - 58s - loss: 0.0156 - val_loss: 0.0299
Epoch 47/200
40/41 [============================>.] - ETA: 1s - loss: 0.0155
```



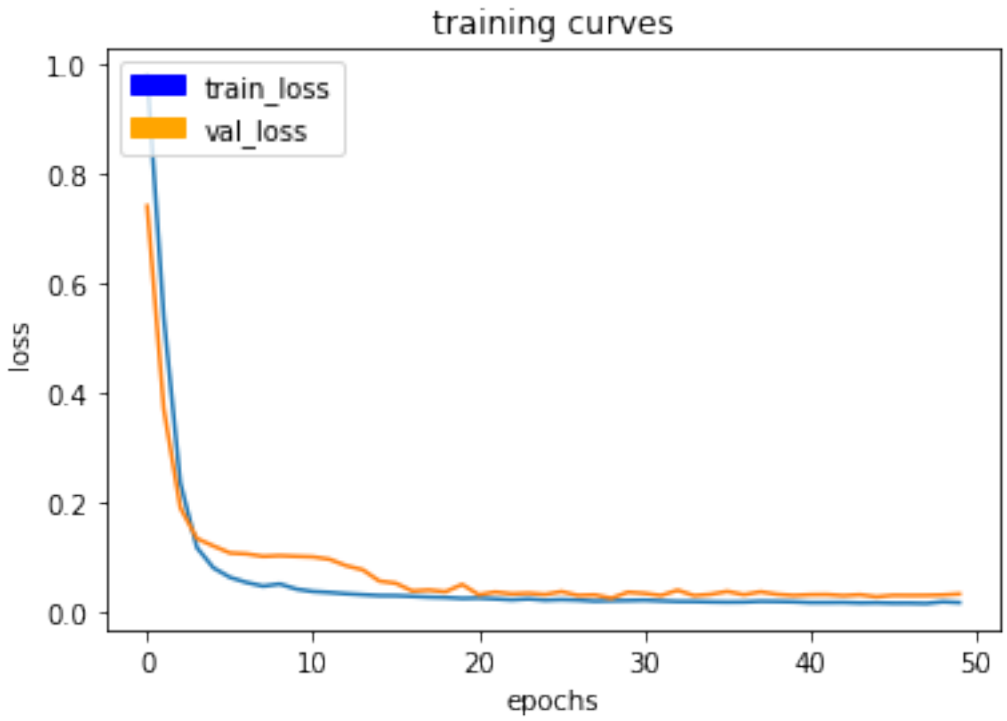

```
41/41 [==============================] - 57s - loss: 0.0156 - val_loss: 0.0297
Epoch 48/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0151
```



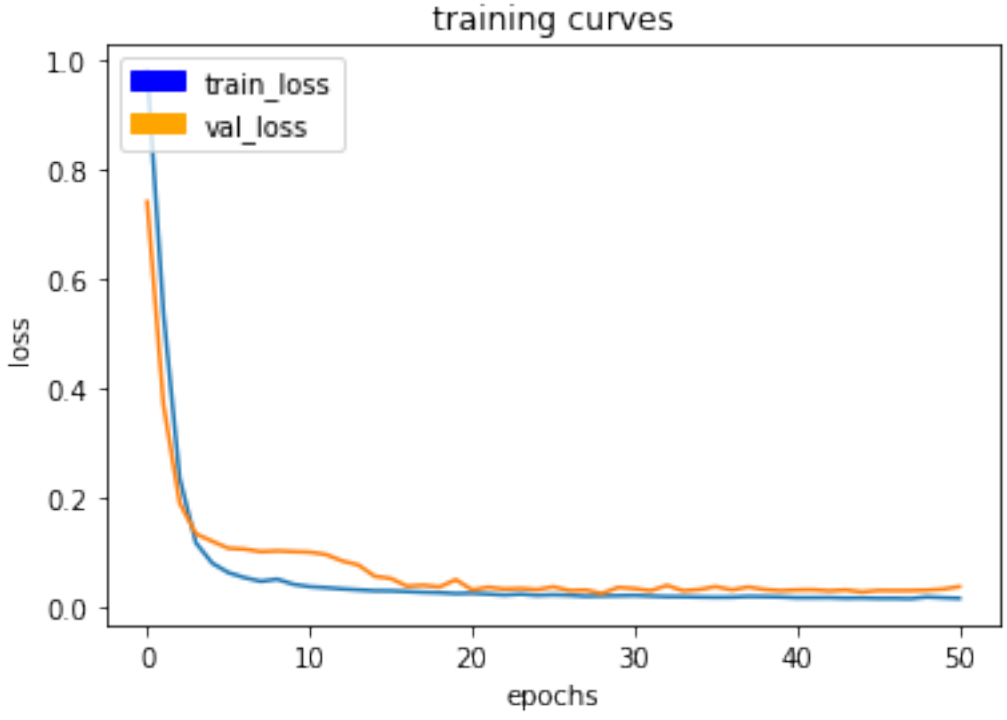
```
41/41 [==============================] - 58s - loss: 0.0151 - val_loss: 0.0298
Epoch 49/200
40/41 [============================>.] - ETA: 1s - loss: 0.0181
```



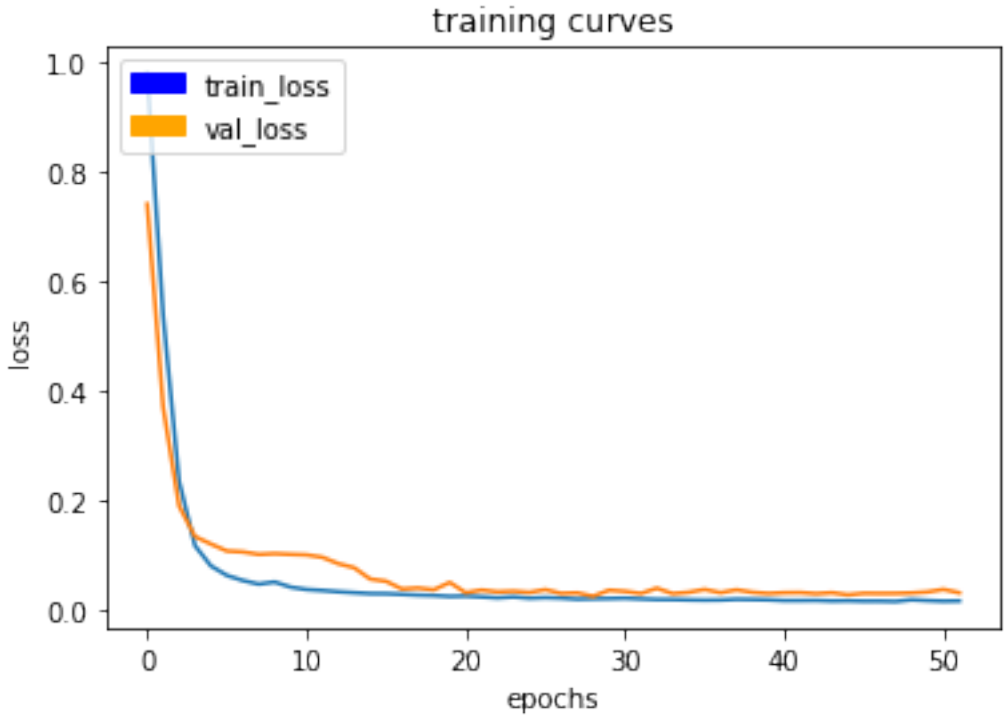

```
41/41 [==============================] - 58s - loss: 0.0181 - val_loss: 0.0306
Epoch 50/200
40/41 [============================>.] - ETA: 1s - loss: 0.0168
```



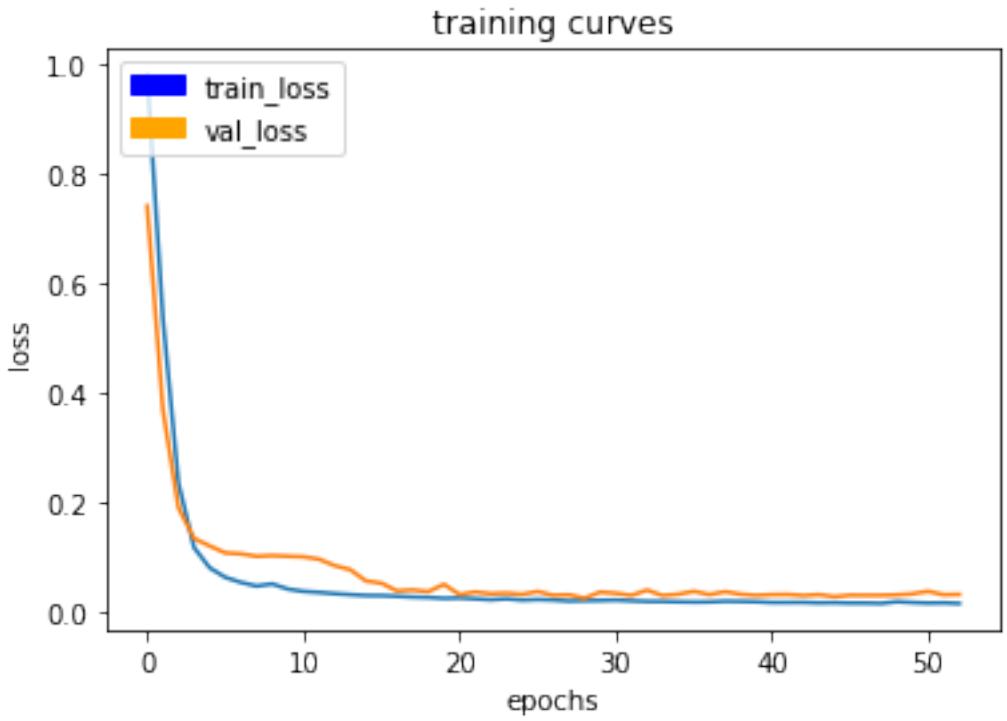

```
41/41 [==============================] - 58s - loss: 0.0167 - val_loss: 0.0324
Epoch 51/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0157
```



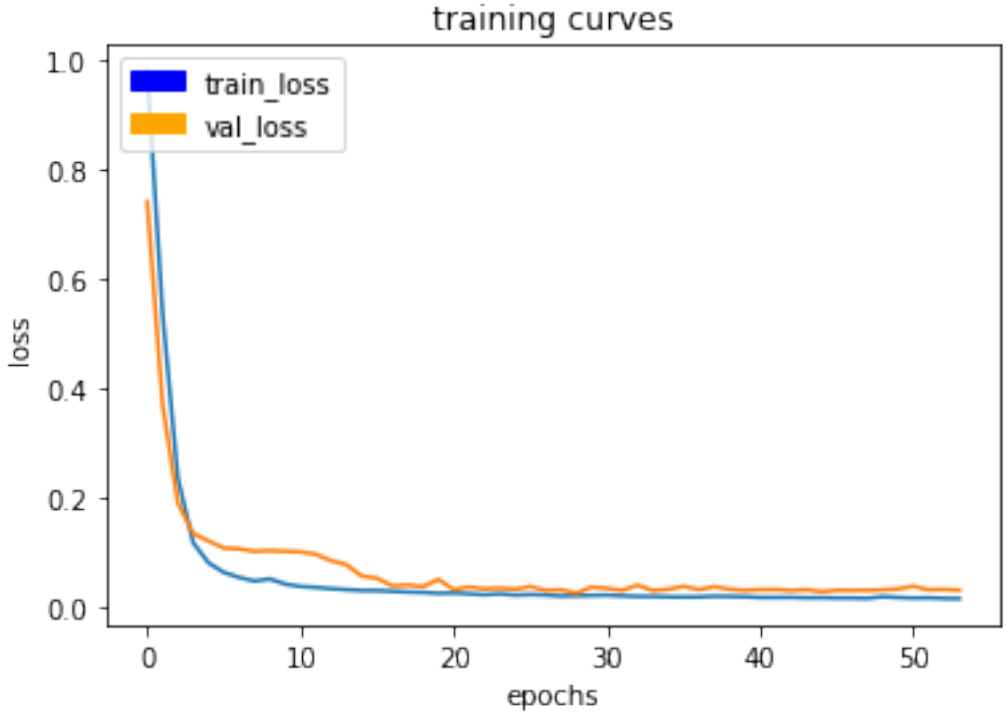
```
41/41 [==============================] - 57s - loss: 0.0156 - val_loss: 0.0371
Epoch 52/200
40/41 [============================>.] - ETA: 1s - loss: 0.0161
```



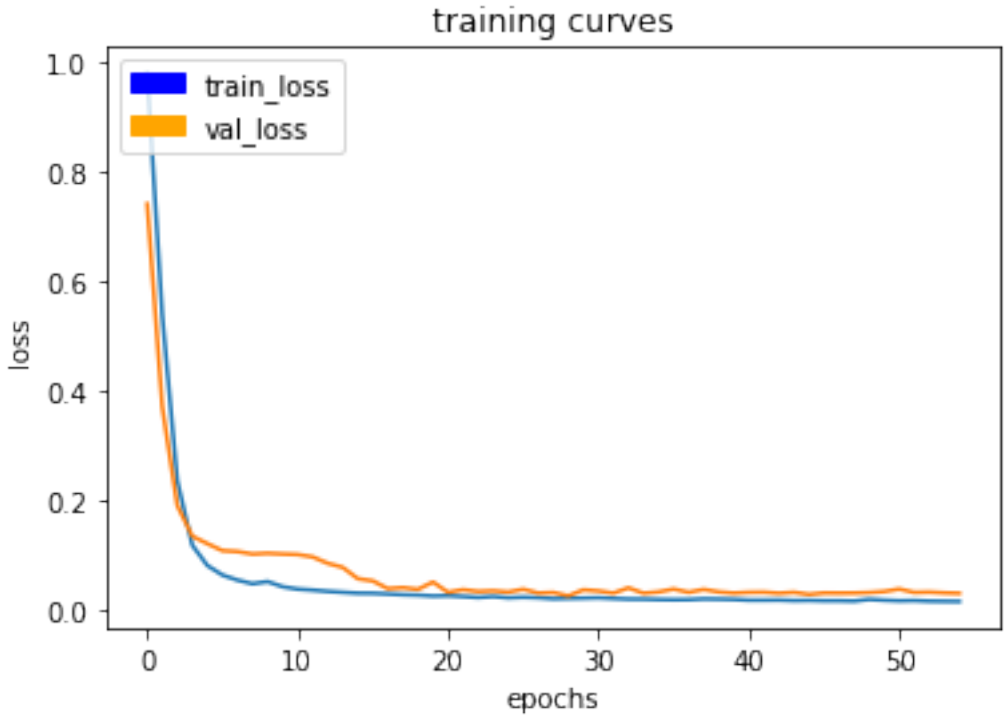

```
41/41 [==============================] - 58s - loss: 0.0160 - val_loss: 0.0309
Epoch 53/200
40/41 [============================>.] - ETA: 1s - loss: 0.0150
```



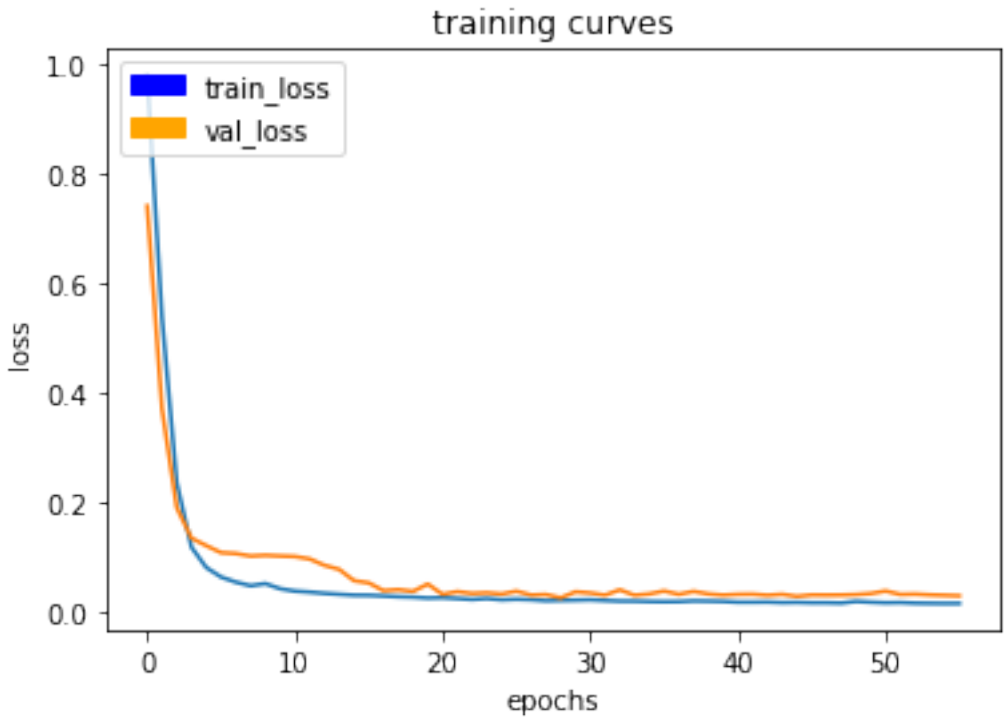

```
41/41 [==============================] - 58s - loss: 0.0150 - val_loss: 0.0314
Epoch 54/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0145
```



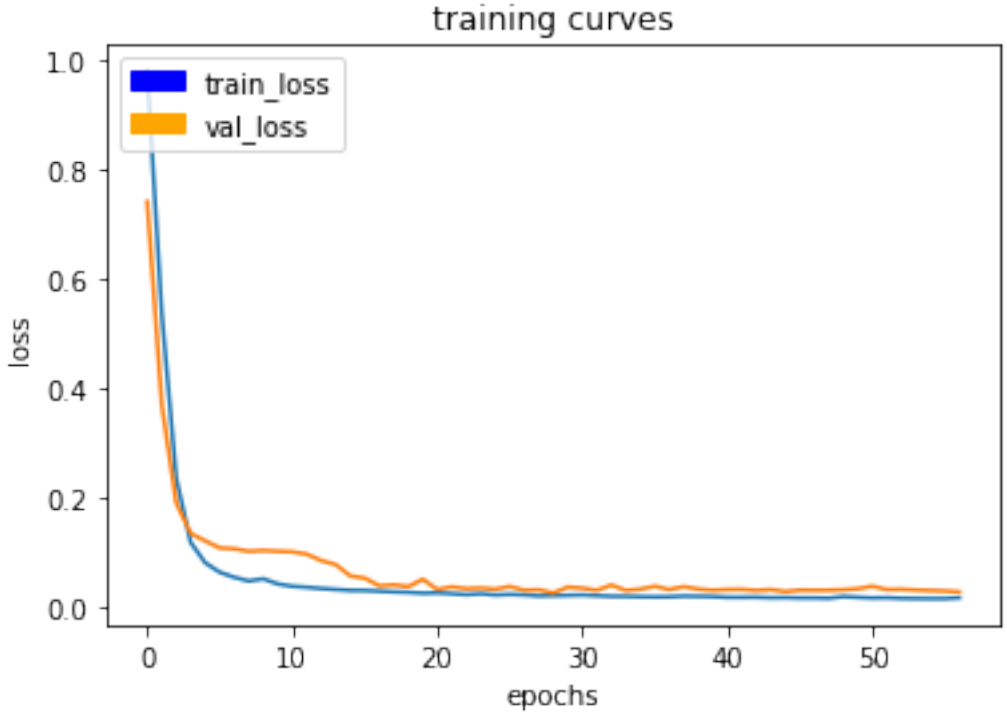
```
41/41 [==============================] - 58s - loss: 0.0145 - val_loss: 0.0300
Epoch 55/200
40/41 [============================>.] - ETA: 1s - loss: 0.0142
```



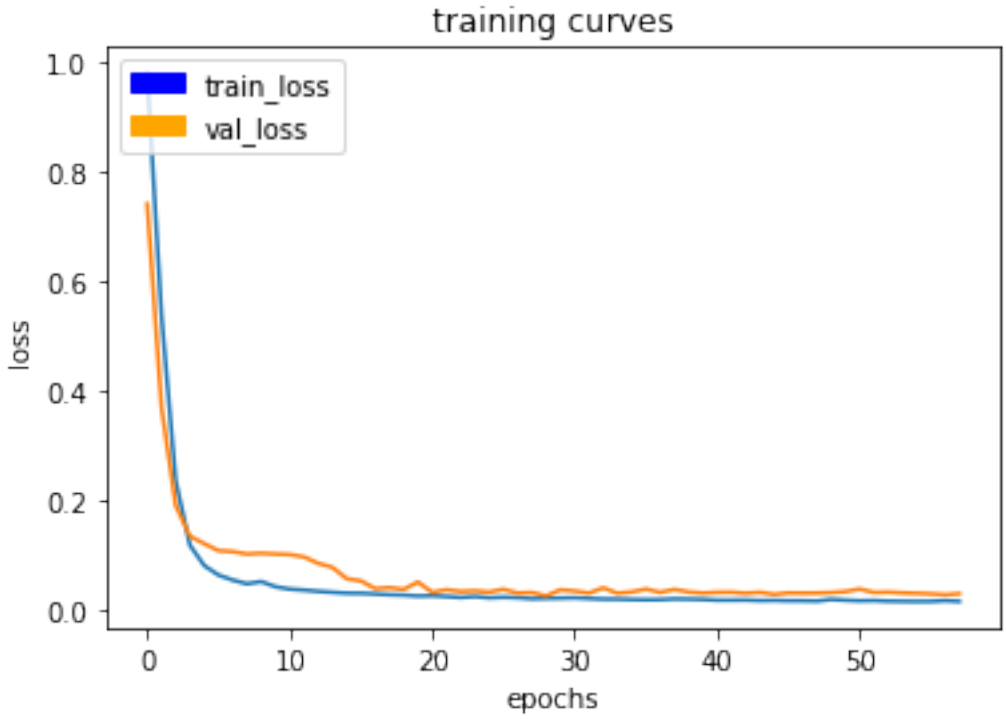

```
41/41 [==============================] - 57s - loss: 0.0143 - val_loss: 0.0292
Epoch 56/200
40/41 [============================>.] - ETA: 1s - loss: 0.0144
```



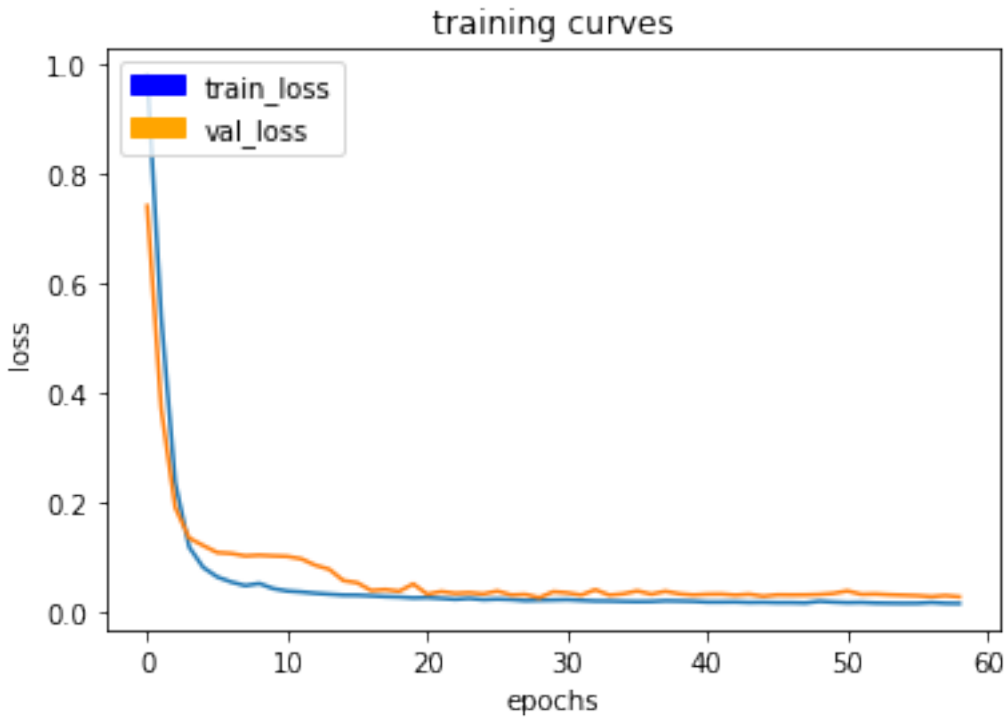

```
41/41 [==============================] - 57s - loss: 0.0144 - val_loss: 0.0284
Epoch 57/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0158
```



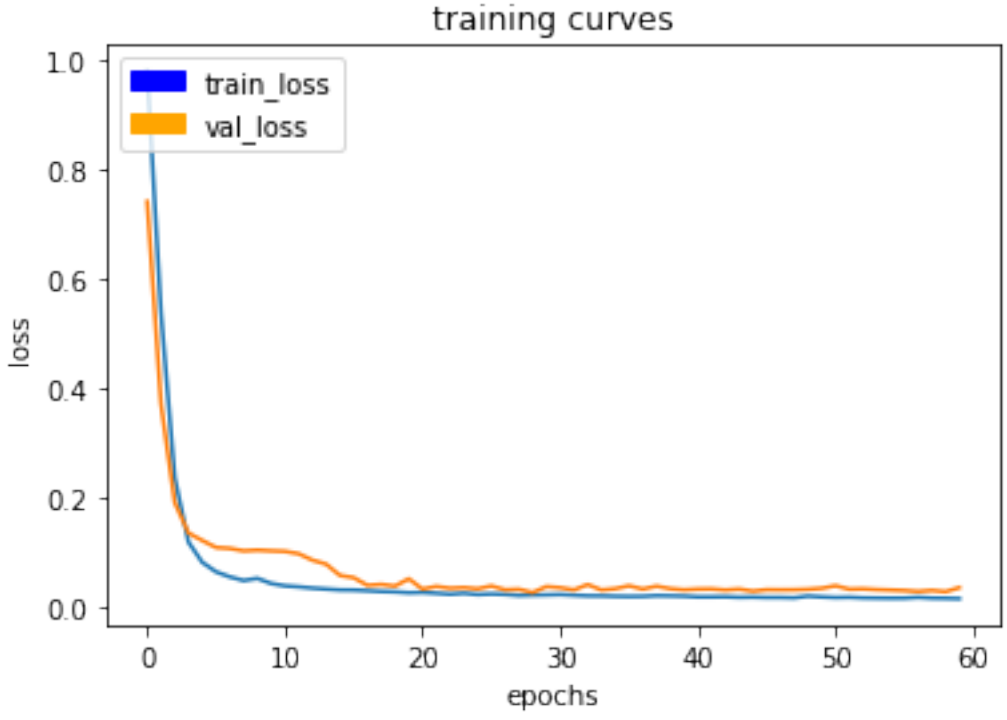
```
41/41 [==============================] - 57s - loss: 0.0158 - val_loss: 0.0266
Epoch 58/200
40/41 [============================>.] - ETA: 1s - loss: 0.0144
```



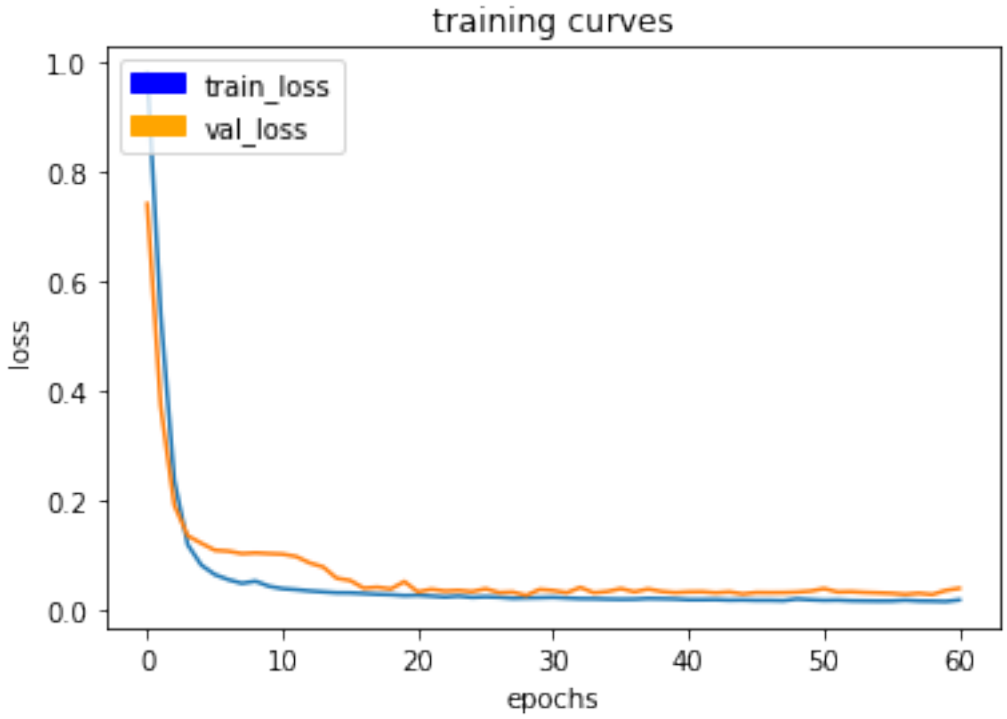

```
41/41 [==============================] - 57s - loss: 0.0144 - val_loss: 0.0285
Epoch 59/200
40/41 [============================>.] - ETA: 1s - loss: 0.0141
```



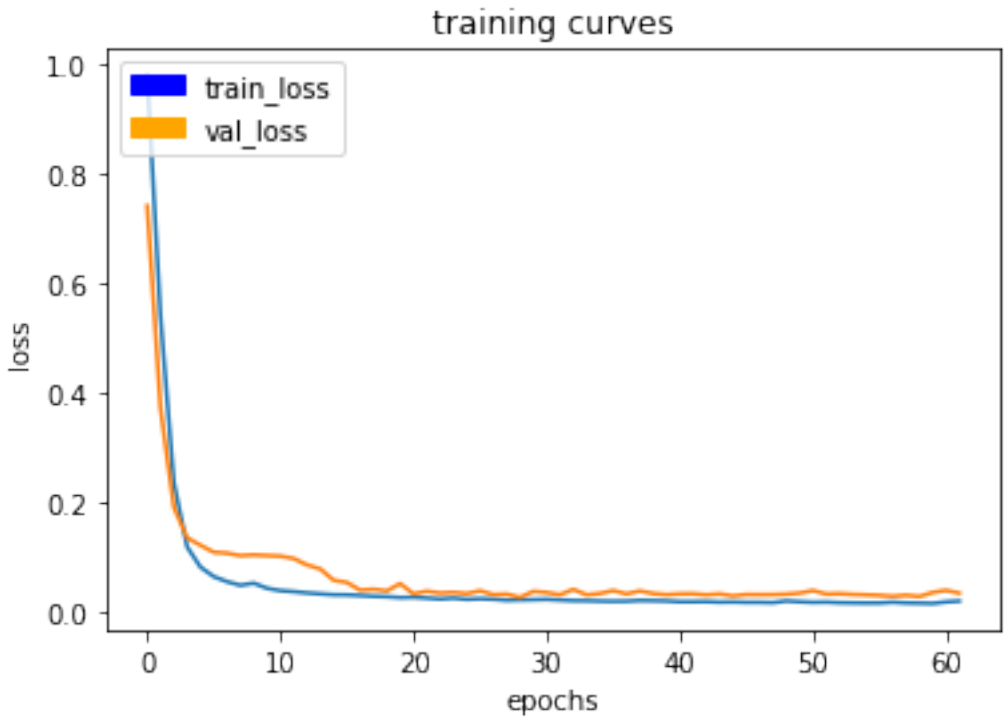

```
41/41 [==============================] - 57s - loss: 0.0141 - val_loss: 0.0262
Epoch 60/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0135
```



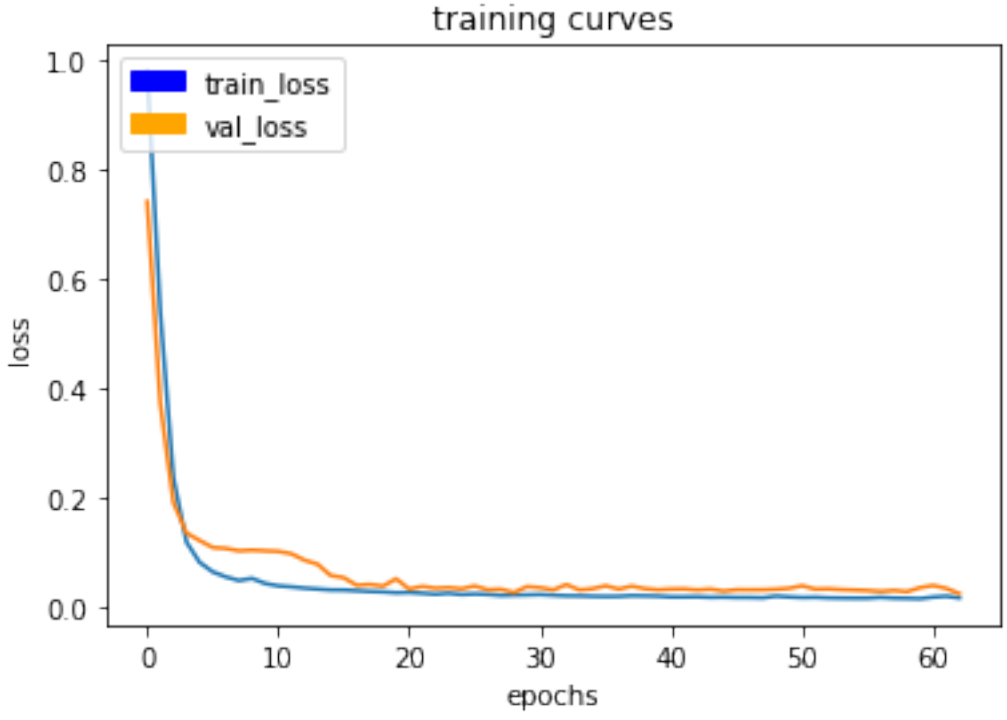
```
41/41 [==============================] - 57s - loss: 0.0135 - val_loss: 0.0337
Epoch 61/200
40/41 [============================>.] - ETA: 1s - loss: 0.0163
```



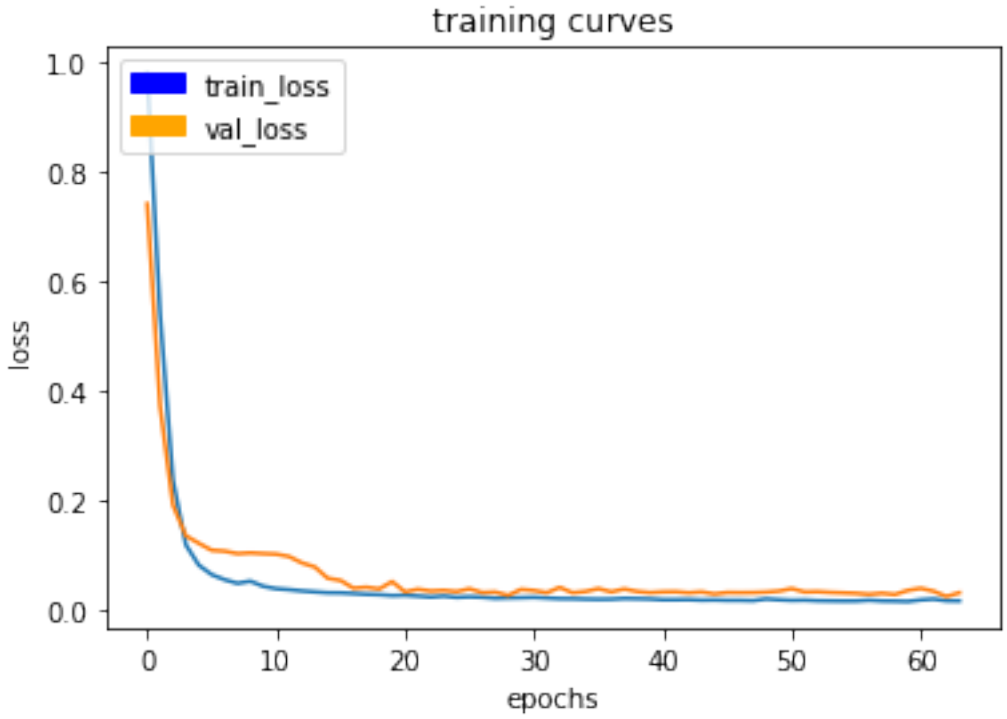

```
41/41 [==============================] - 57s - loss: 0.0165 - val_loss: 0.0376
Epoch 62/200
40/41 [============================>.] - ETA: 1s - loss: 0.0181
```



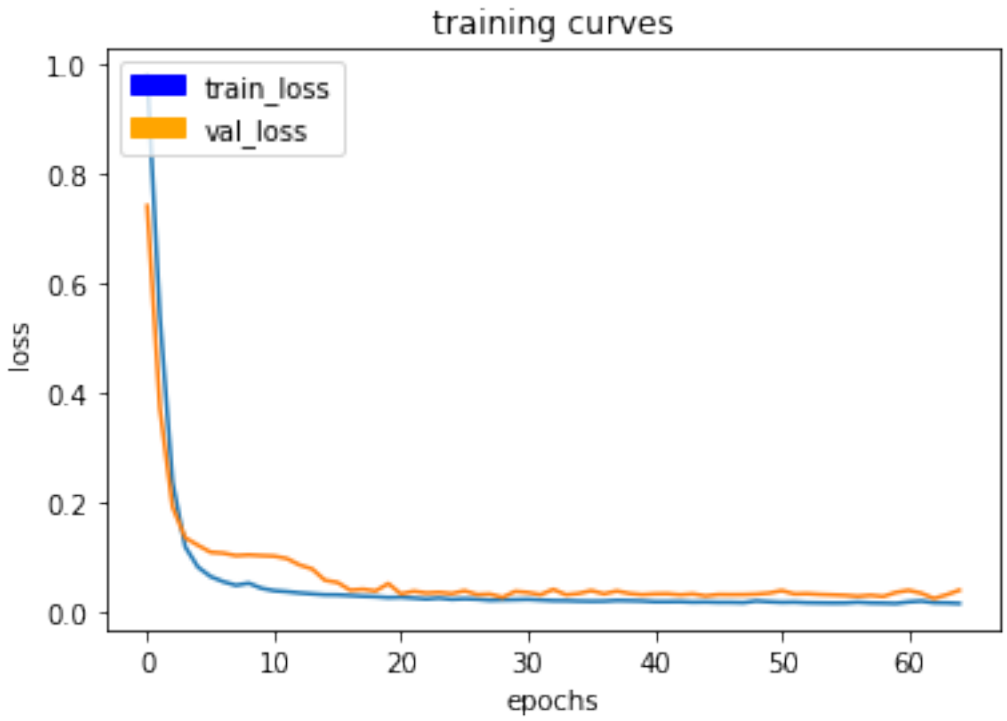

```
41/41 [==============================] - 57s - loss: 0.0180 - val_loss: 0.0323
Epoch 63/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0148
```



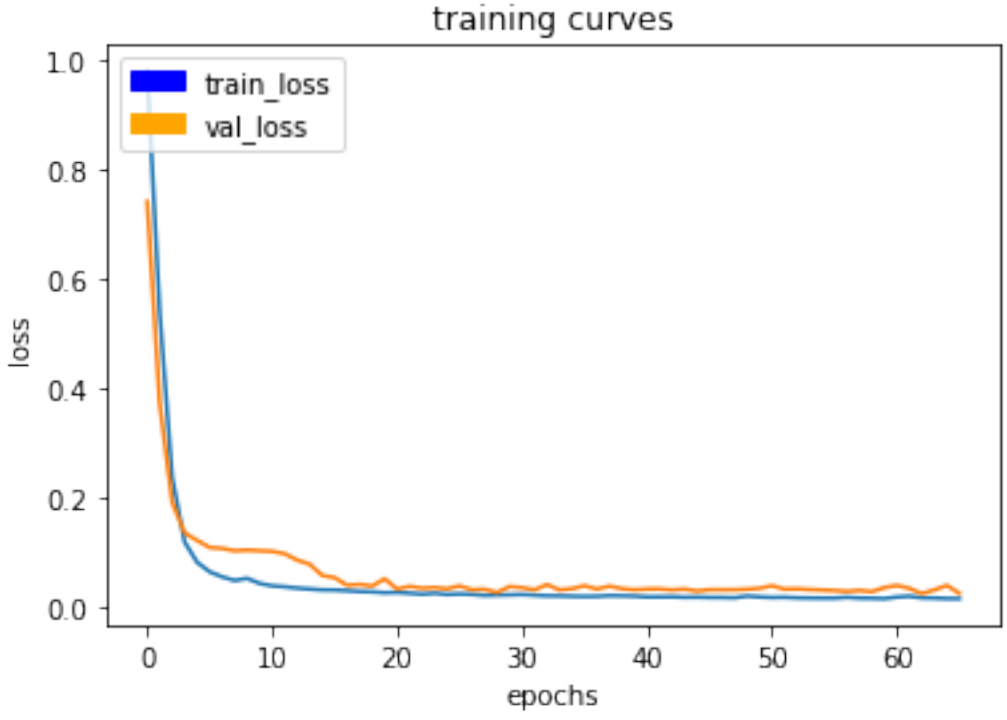
```
41/41 [==============================] - 57s - loss: 0.0148 - val_loss: 0.0226
Epoch 64/200
40/41 [============================>.] - ETA: 1s - loss: 0.0146
```



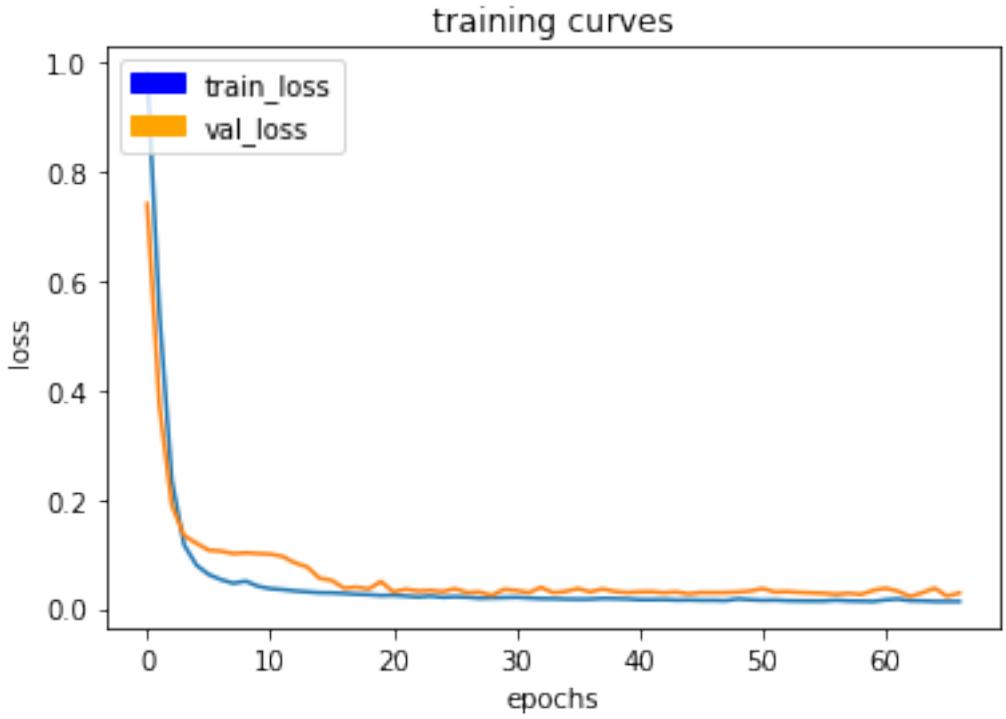

```
41/41 [==============================] - 57s - loss: 0.0145 - val_loss: 0.0295
Epoch 65/200
40/41 [============================>.] - ETA: 1s - loss: 0.0136
```



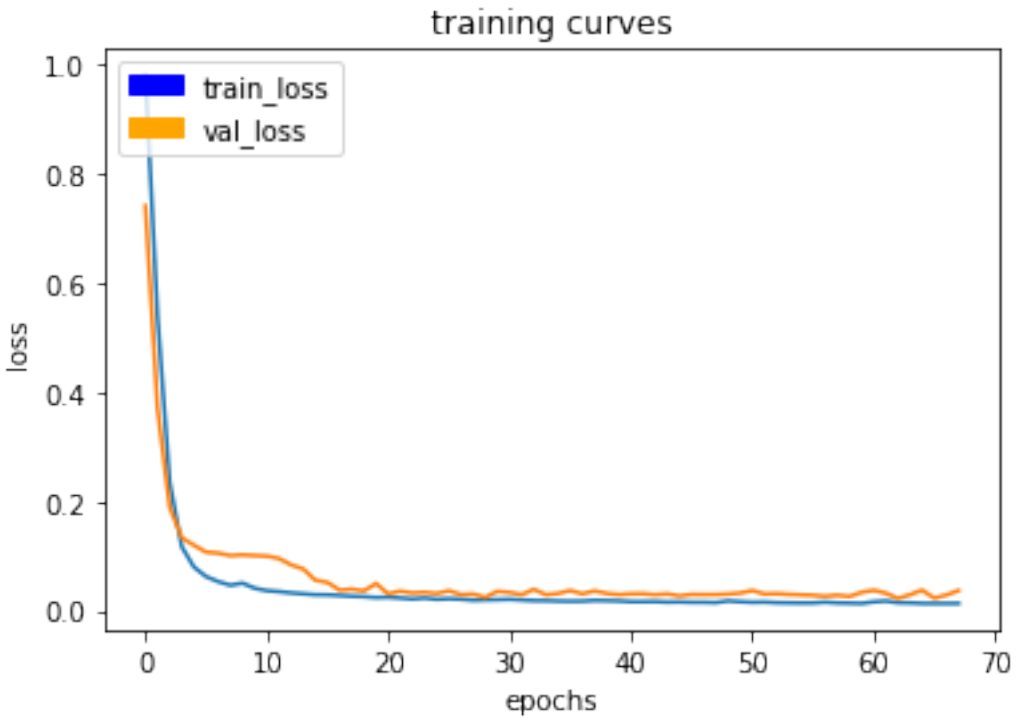

```
41/41 [==============================] - 57s - loss: 0.0136 - val_loss: 0.0378
Epoch 66/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0135
```



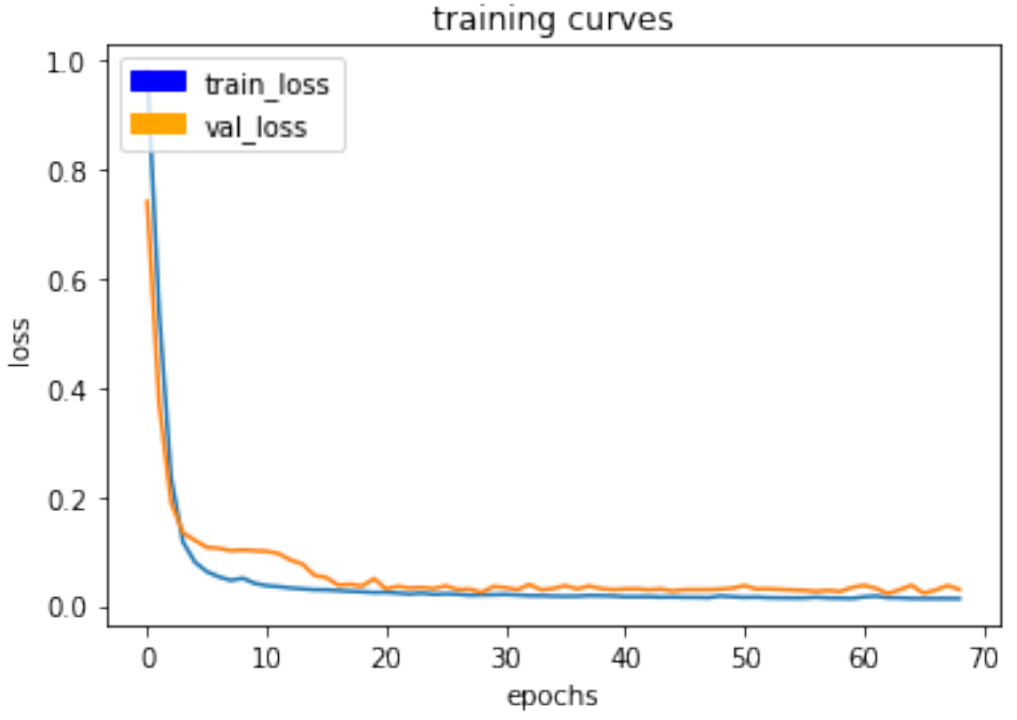
```
41/41 [==============================] - 57s - loss: 0.0134 - val_loss: 0.0230
Epoch 67/200
40/41 [============================>.] - ETA: 1s - loss: 0.0134
```



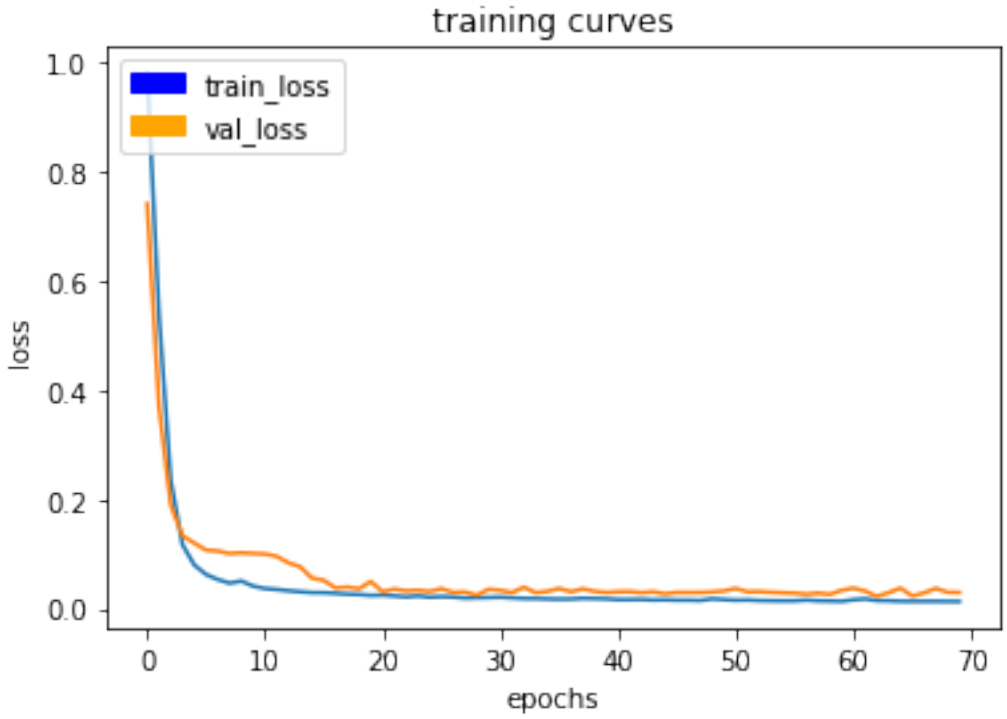

```
41/41 [==============================] - 57s - loss: 0.0134 - val_loss: 0.0289
Epoch 68/200
40/41 [============================>.] - ETA: 1s - loss: 0.0135
```



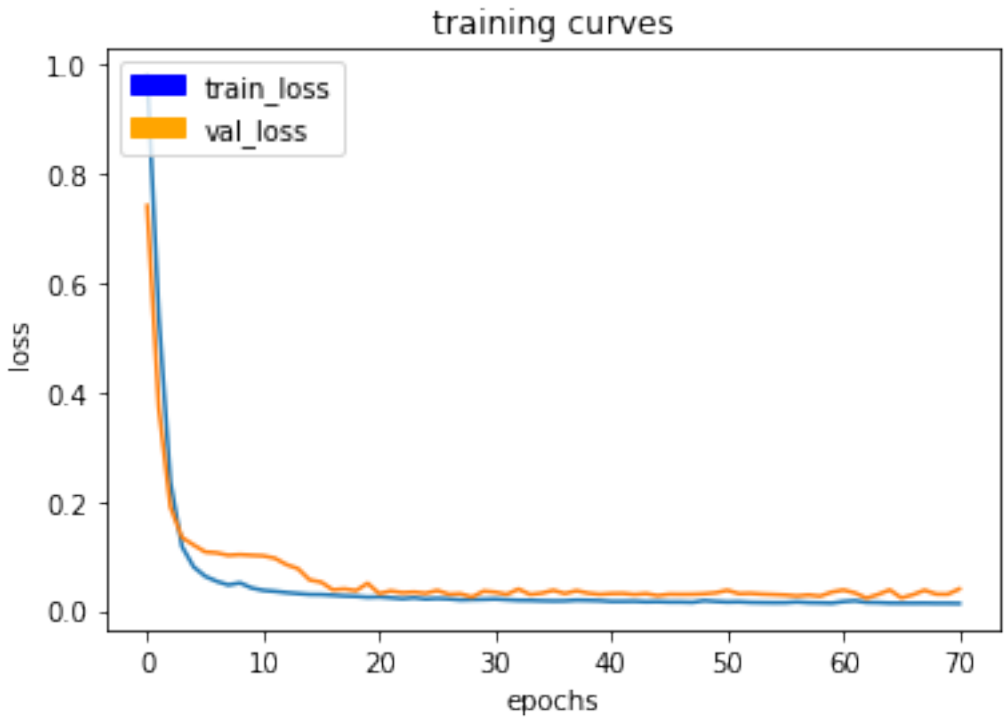

```
41/41 [==============================] - 57s - loss: 0.0135 - val_loss: 0.0372
Epoch 69/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0132
```



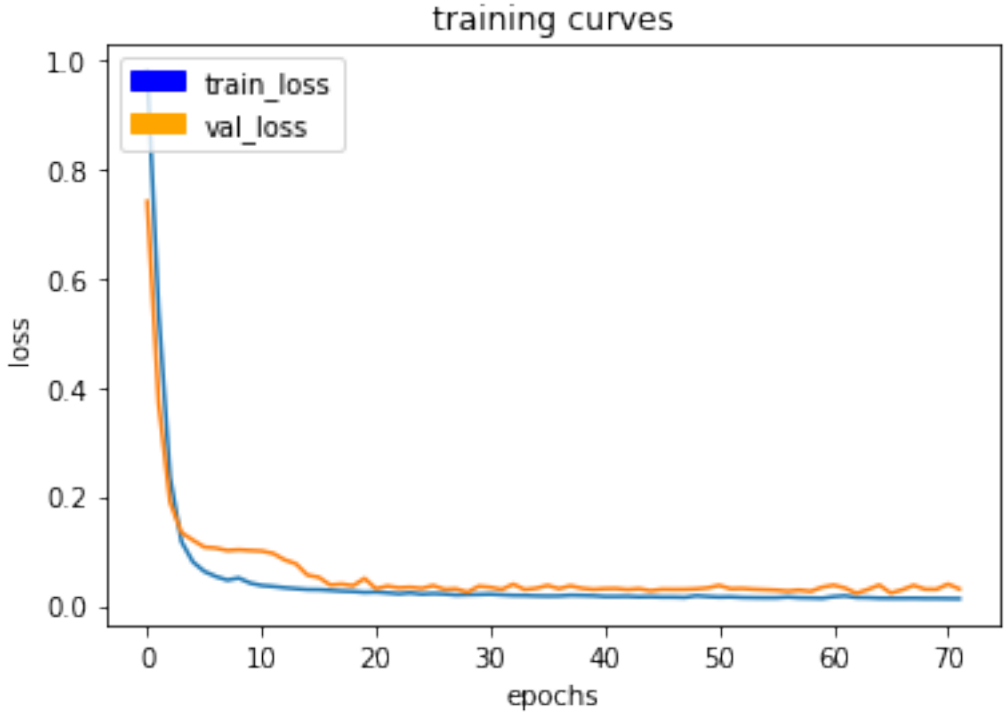
```
41/41 [==============================] - 57s - loss: 0.0132 - val_loss: 0.0300
Epoch 70/200
40/41 [============================>.] - ETA: 1s - loss: 0.0132
```



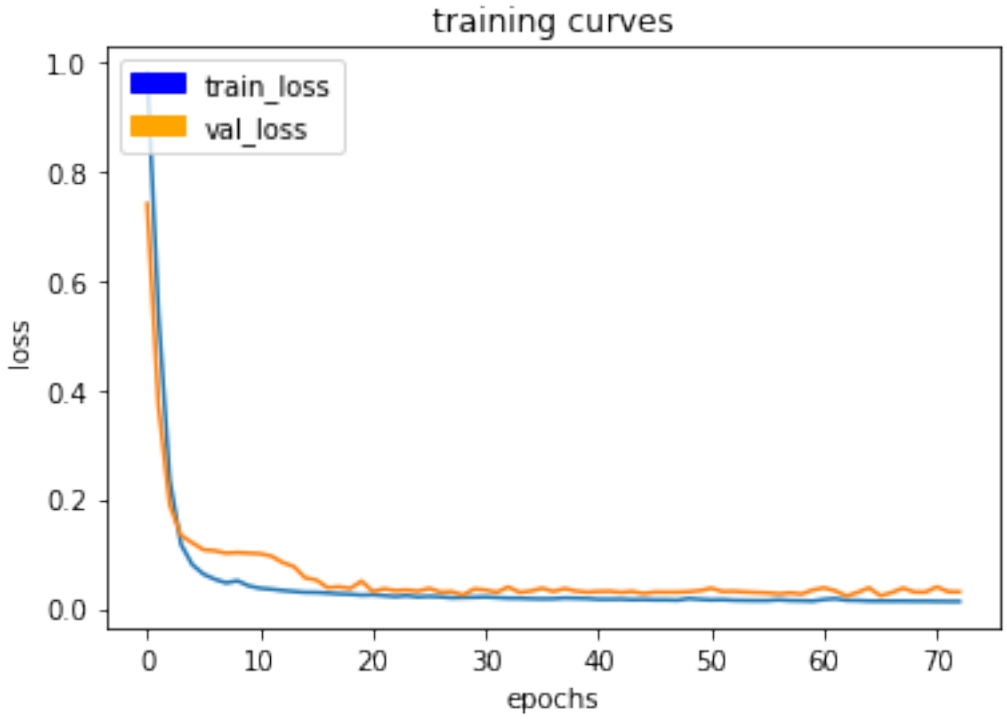

```
41/41 [==============================] - 58s - loss: 0.0132 - val_loss: 0.0298
Epoch 71/200
40/41 [============================>.] - ETA: 1s - loss: 0.0129
```



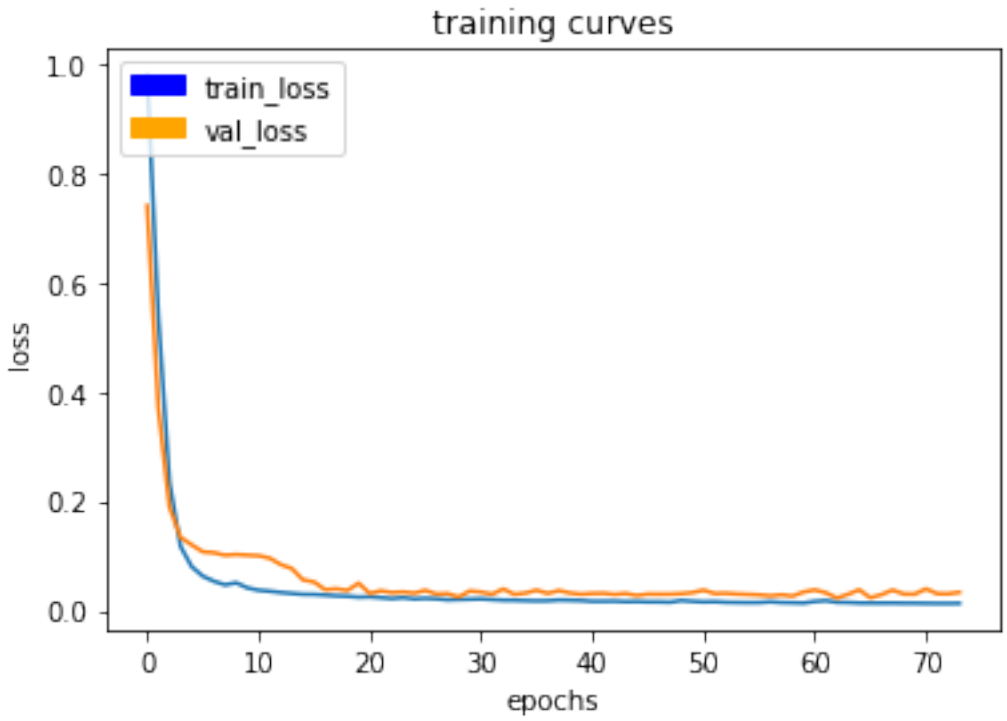

```
41/41 [==============================] - 57s - loss: 0.0129 - val_loss: 0.0395
Epoch 72/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0128
```



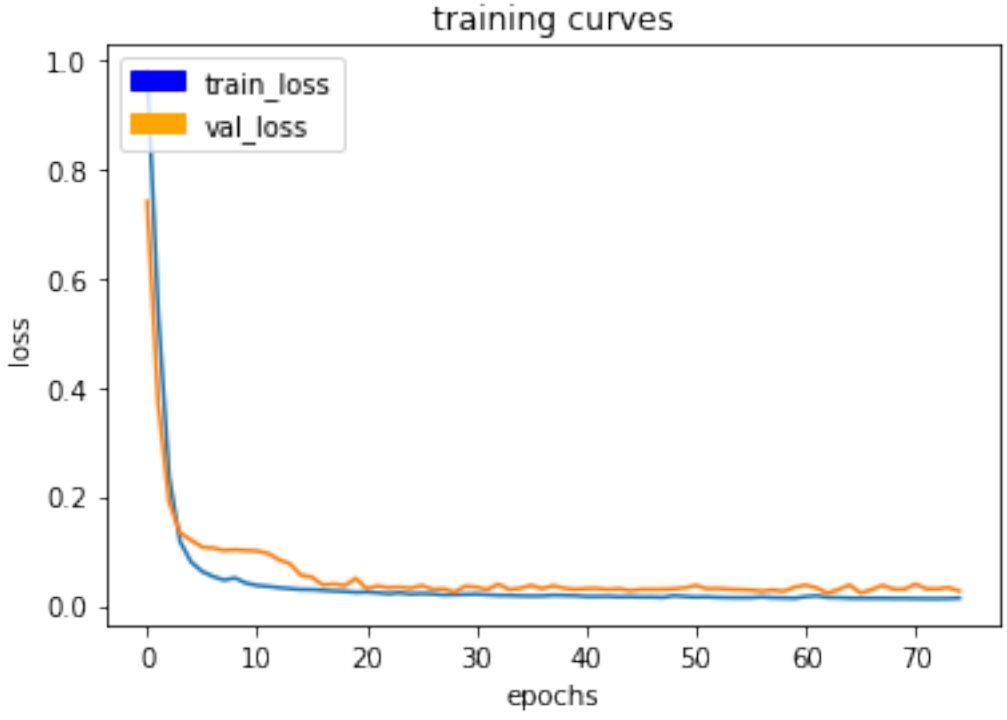
```
41/41 [==============================] - 58s - loss: 0.0127 - val_loss: 0.0306
Epoch 73/200
40/41 [============================>.] - ETA: 1s - loss: 0.0127
```



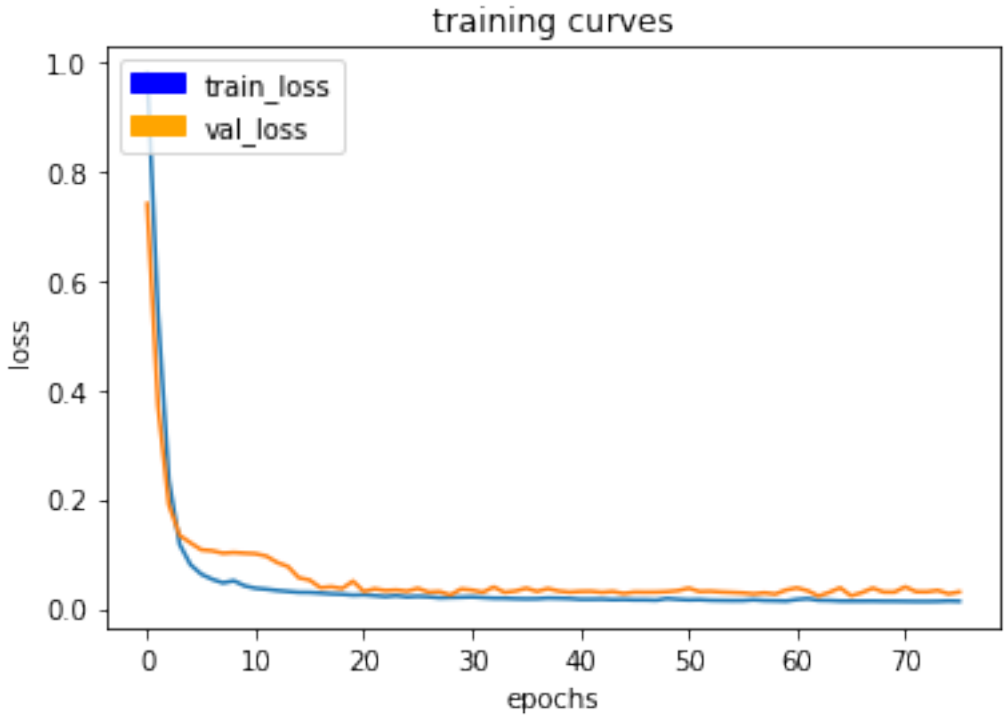

```
41/41 [==============================] - 58s - loss: 0.0127 - val_loss: 0.0304
Epoch 74/200
40/41 [============================>.] - ETA: 1s - loss: 0.0129
```



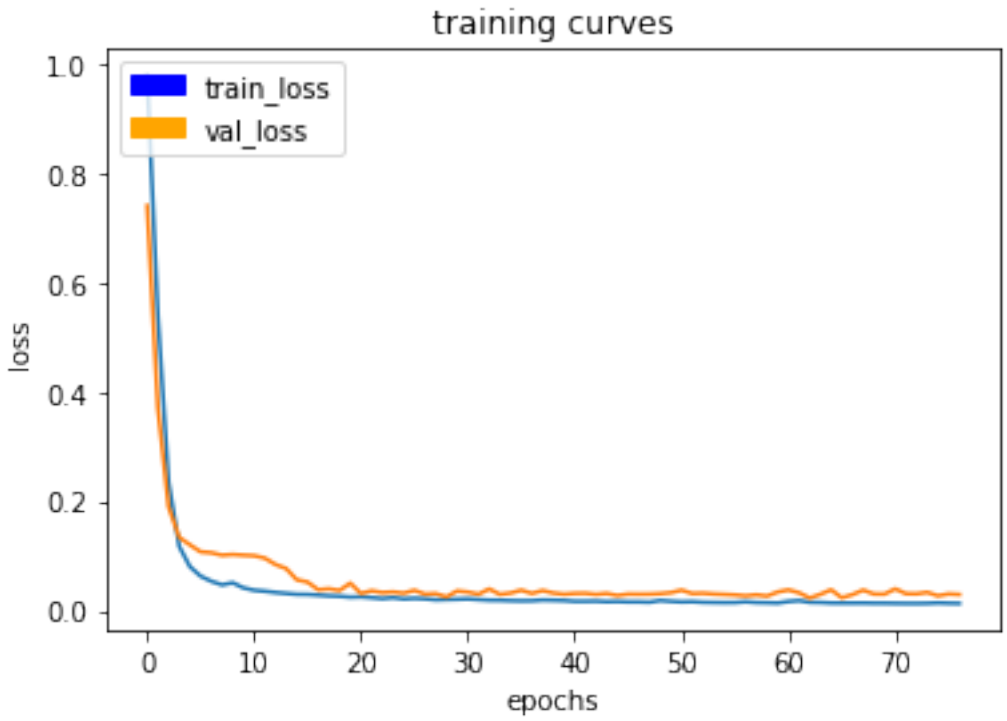

```
41/41 [==============================] - 57s - loss: 0.0129 - val_loss: 0.0330
Epoch 75/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0138
```



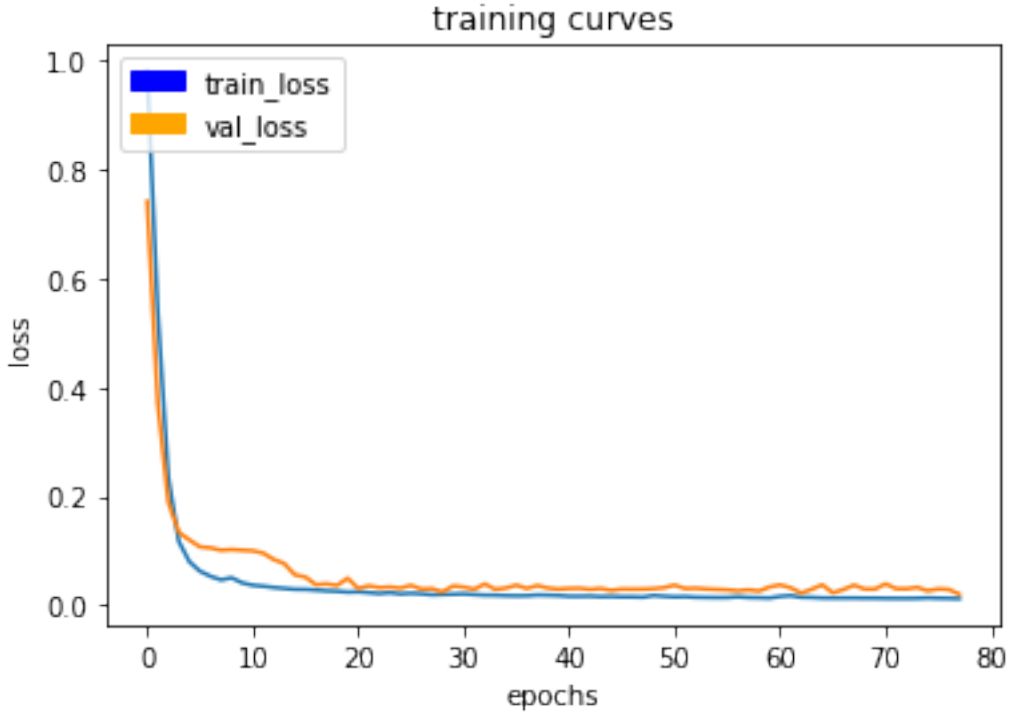
```
41/41 [==============================] - 58s - loss: 0.0137 - val_loss: 0.0267
Epoch 76/200
40/41 [============================>.] - ETA: 1s - loss: 0.0131
```



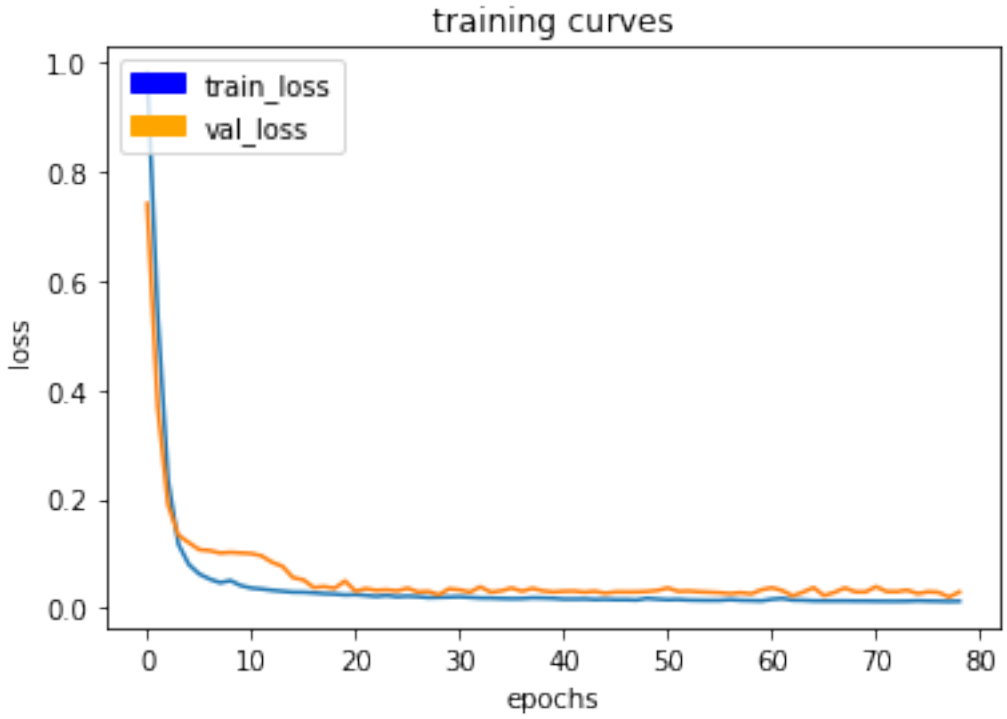

```
41/41 [==============================] - 57s - loss: 0.0131 - val_loss: 0.0302
Epoch 77/200
40/41 [============================>.] - ETA: 1s - loss: 0.0128
```



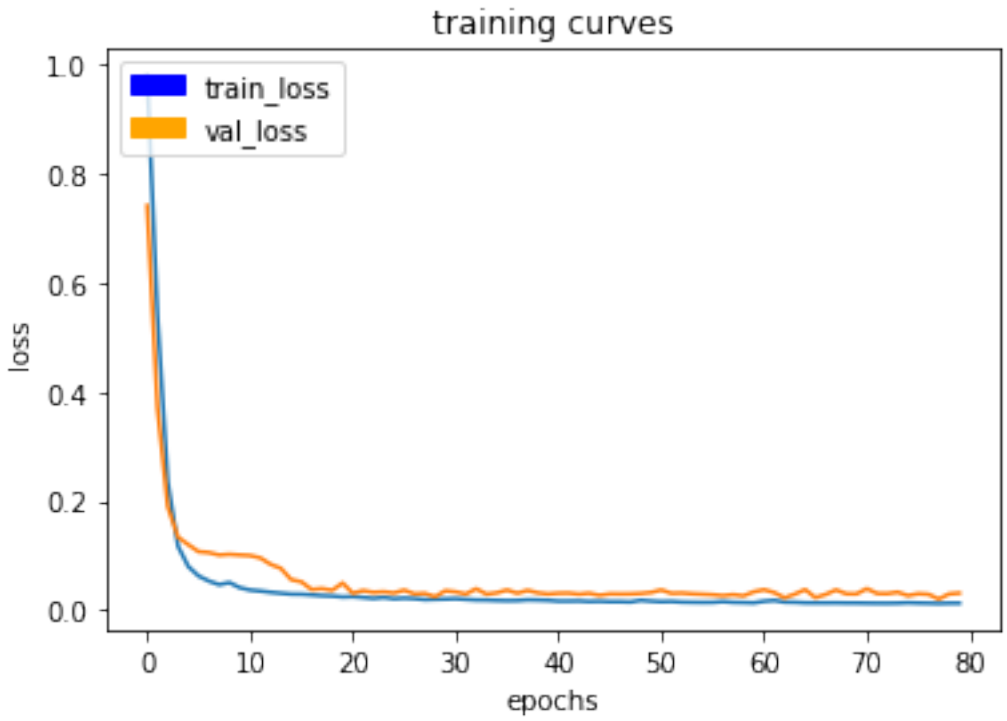

```
41/41 [==============================] - 57s - loss: 0.0128 - val_loss: 0.0291
Epoch 78/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0123
```



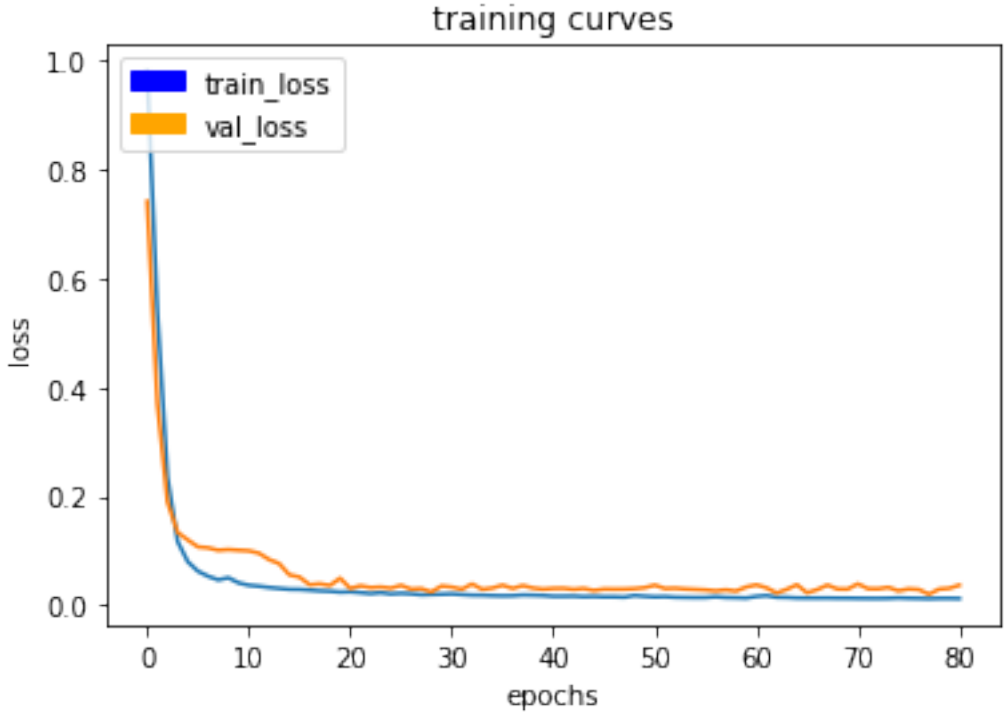
```
41/41 [==============================] - 57s - loss: 0.0123 - val_loss: 0.0203
Epoch 79/200
40/41 [============================>.] - ETA: 1s - loss: 0.0129
```



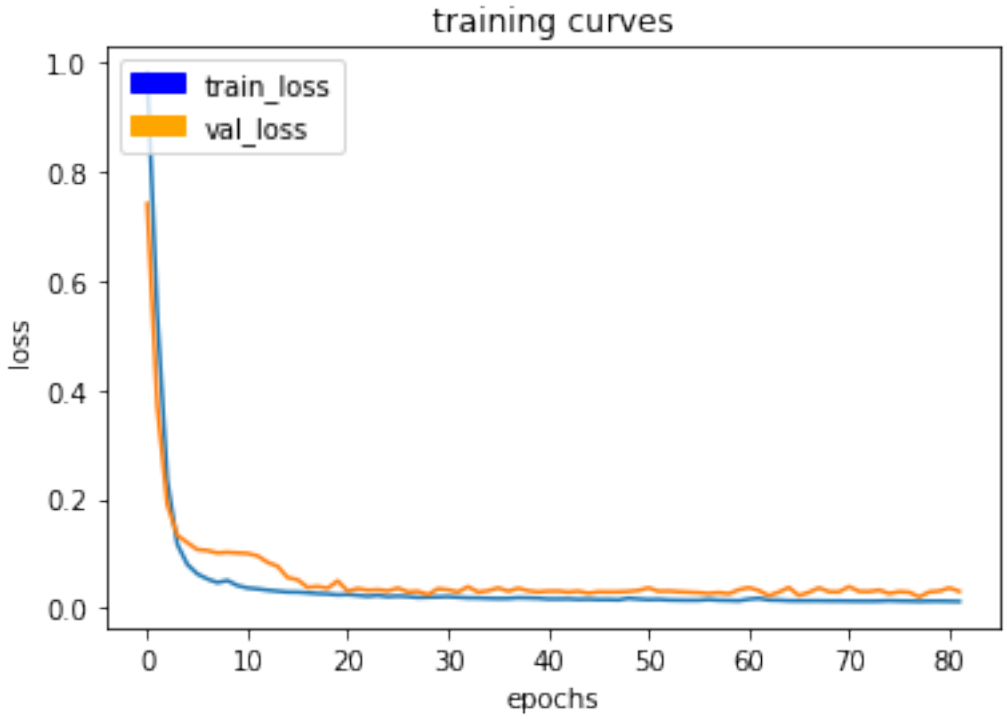

```
41/41 [==============================] - 57s - loss: 0.0129 - val_loss: 0.0298
Epoch 80/200
40/41 [============================>.] - ETA: 1s - loss: 0.0129
```



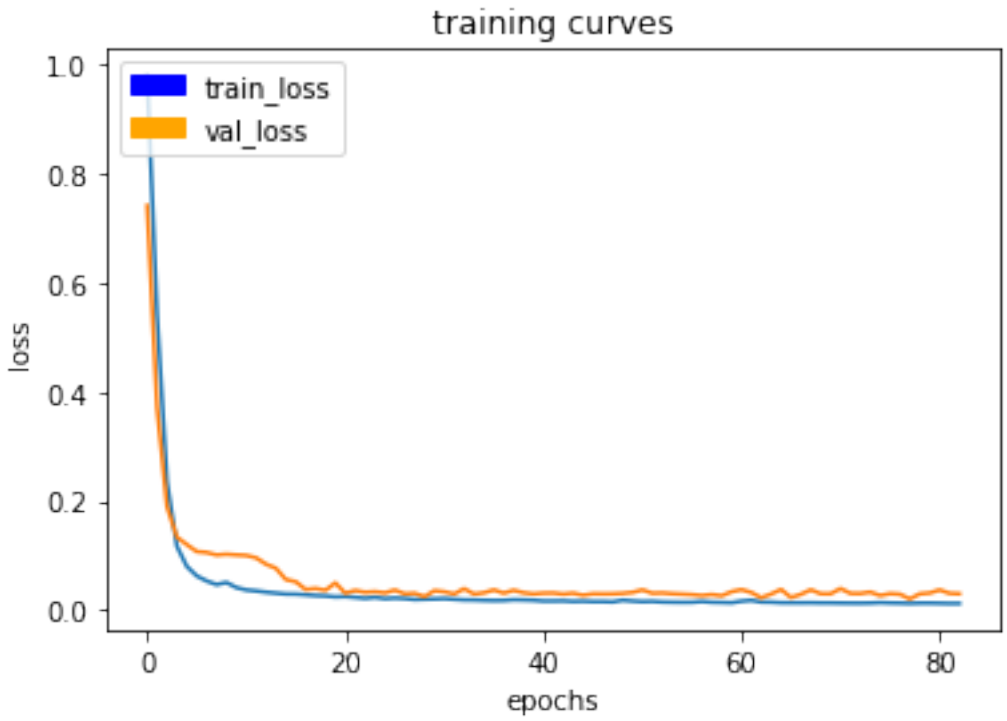

```
41/41 [==============================] - 58s - loss: 0.0129 - val_loss: 0.0313
Epoch 81/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0125
```



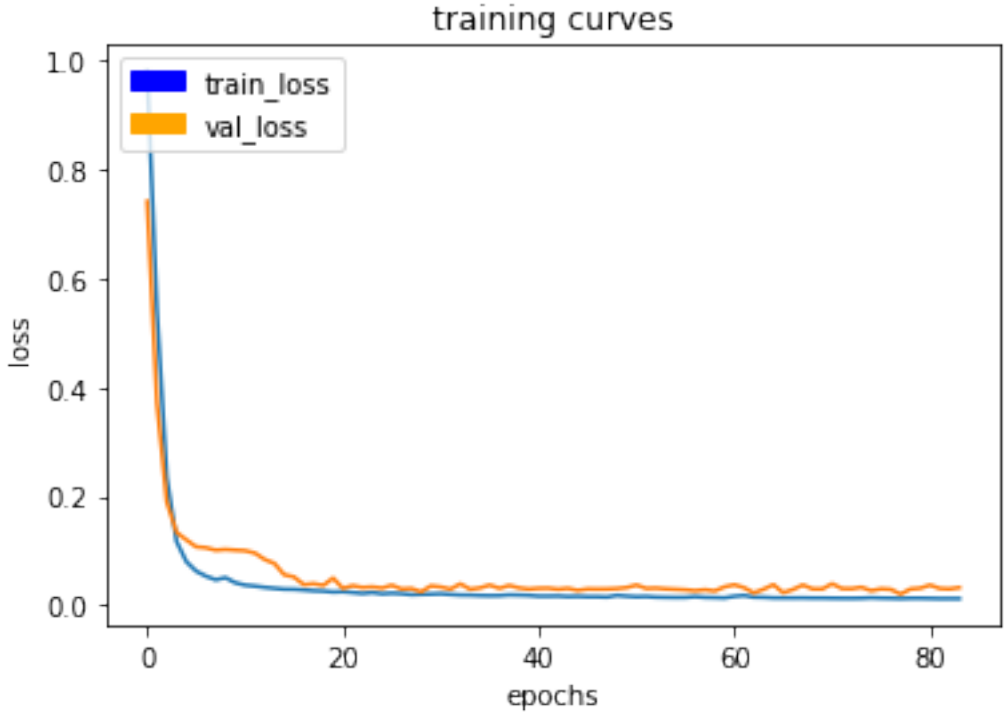
```
41/41 [==============================] - 57s - loss: 0.0125 - val_loss: 0.0370
Epoch 82/200
40/41 [============================>.] - ETA: 1s - loss: 0.0122
```



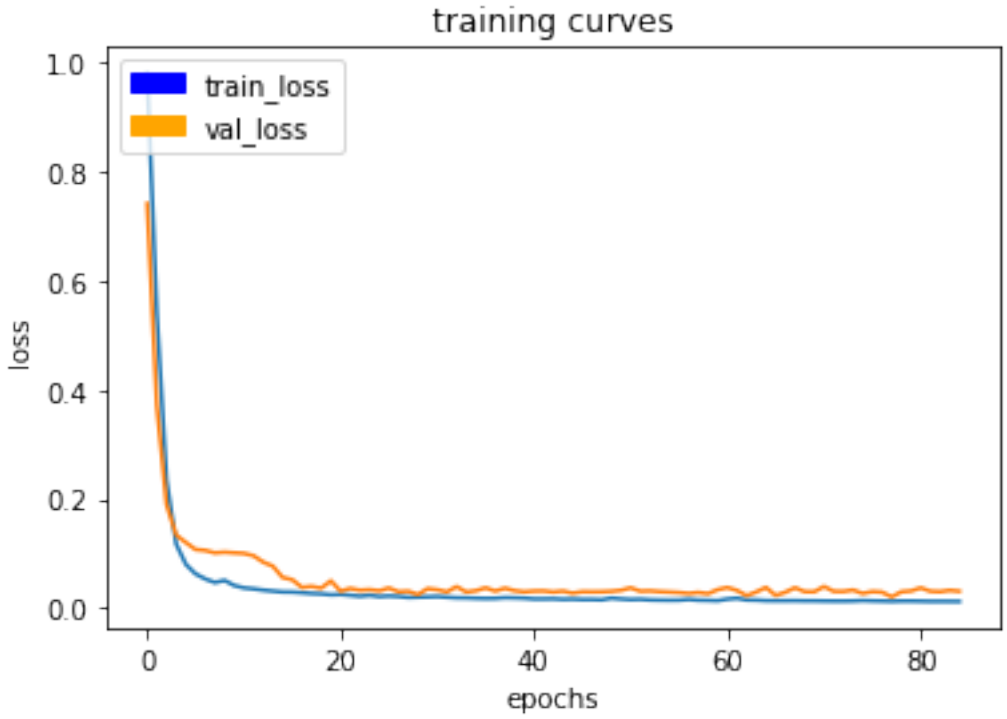

```
41/41 [==============================] - 57s - loss: 0.0122 - val_loss: 0.0307
Epoch 83/200
40/41 [============================>.] - ETA: 1s - loss: 0.0122
```



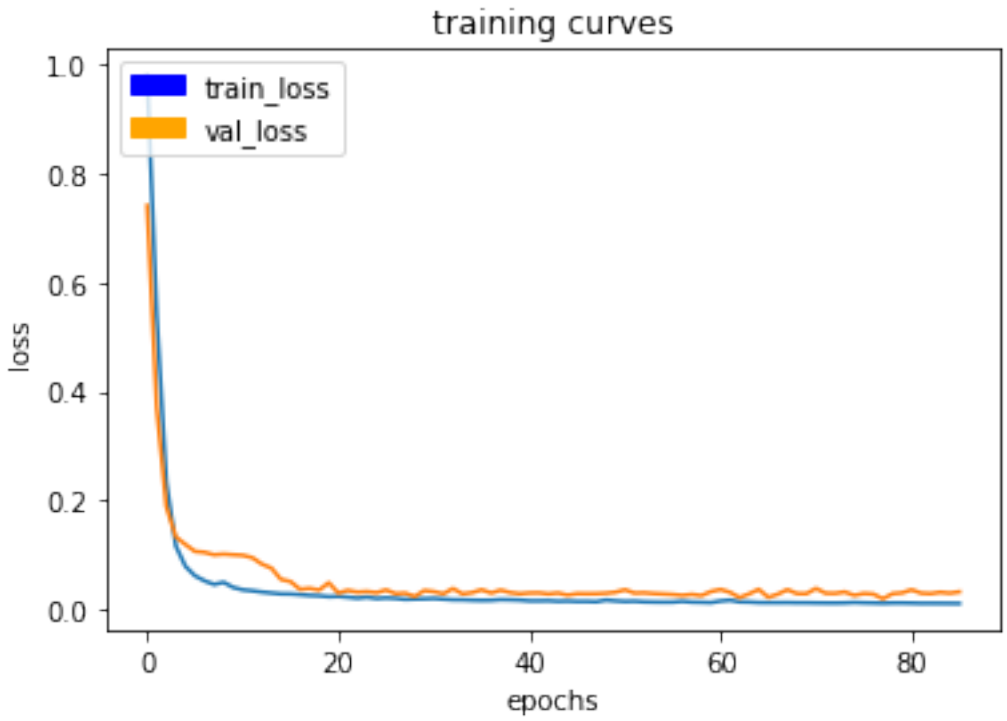

```
41/41 [==============================] - 58s - loss: 0.0122 - val_loss: 0.0300
Epoch 84/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0121
```



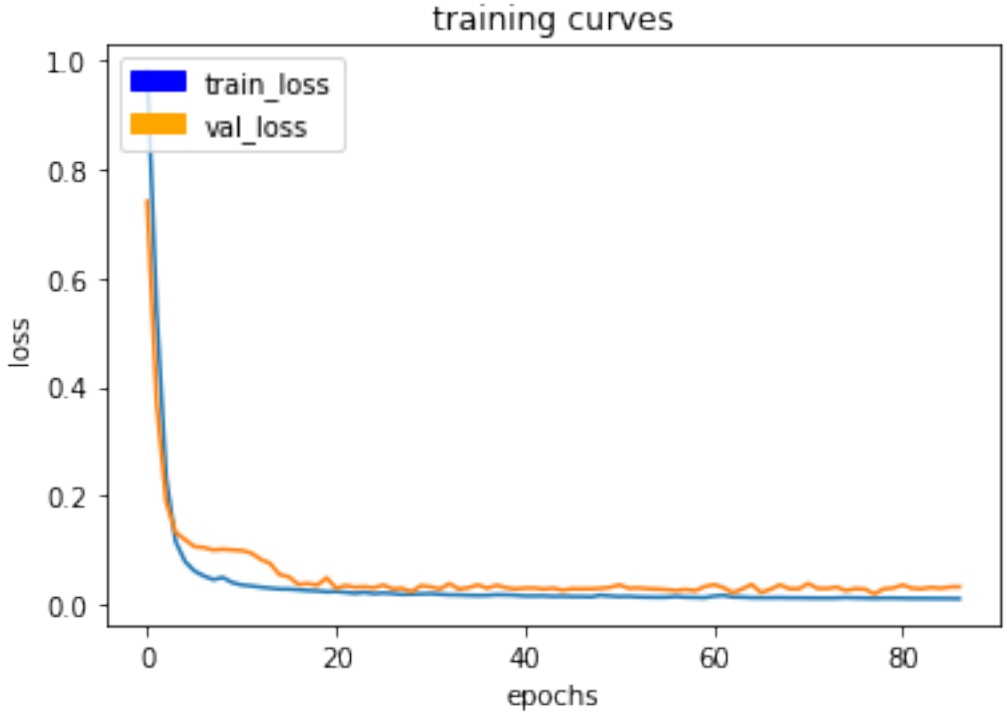
```
41/41 [==============================] - 57s - loss: 0.0121 - val_loss: 0.0324
Epoch 85/200
40/41 [============================>.] - ETA: 1s - loss: 0.0120
```



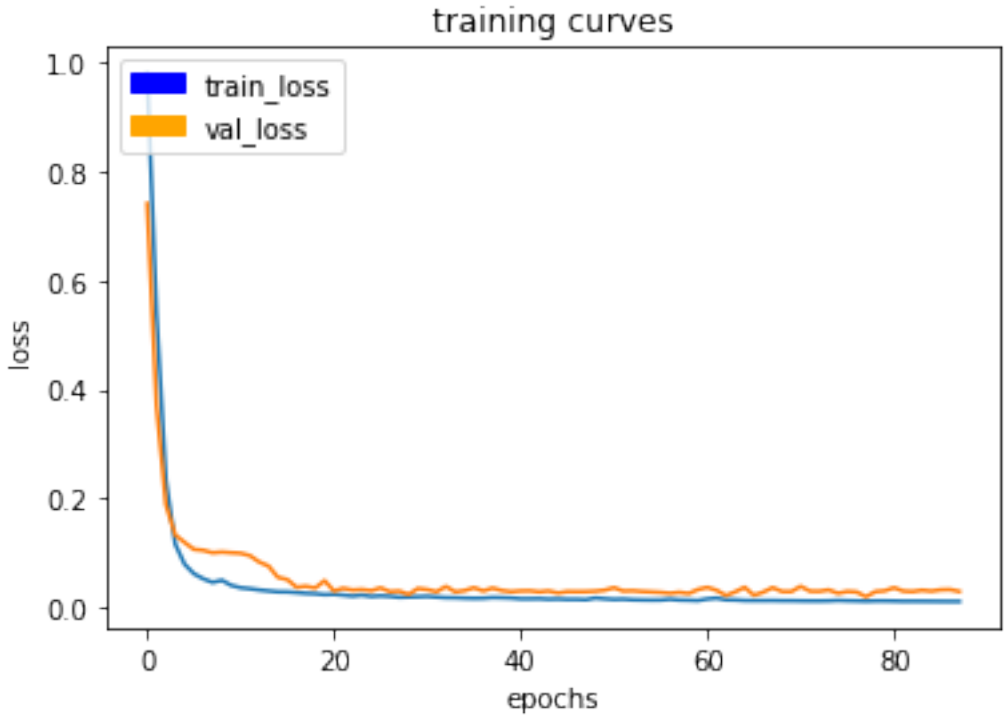

```
41/41 [==============================] - 57s - loss: 0.0120 - val_loss: 0.0308
Epoch 86/200
40/41 [============================>.] - ETA: 1s - loss: 0.0119
```



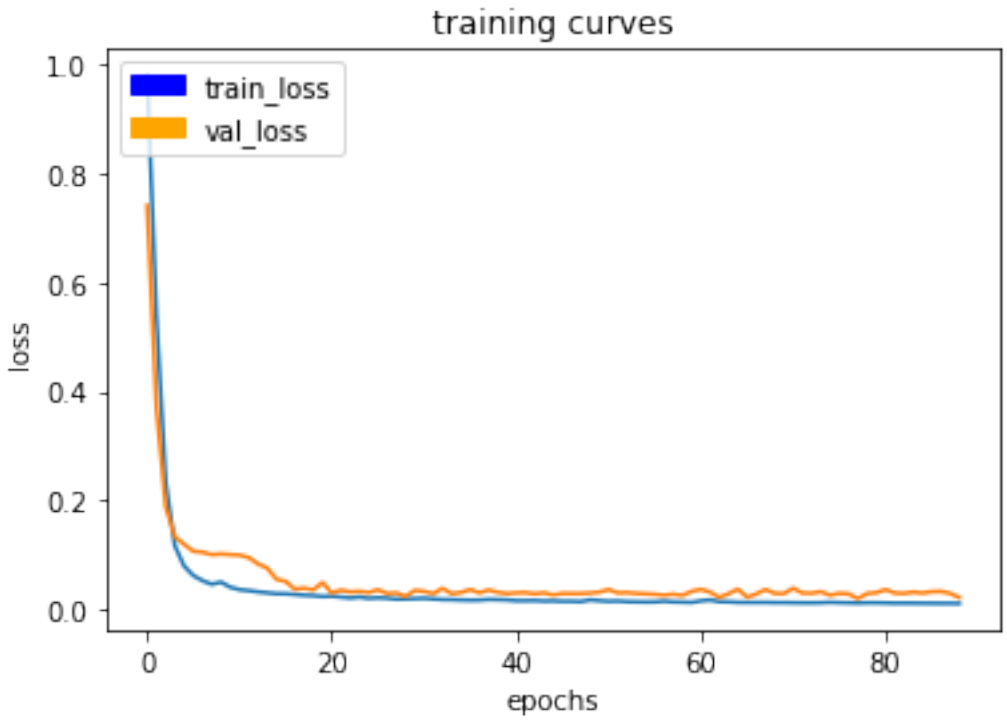

```
41/41 [==============================] - 57s - loss: 0.0119 - val_loss: 0.0331
Epoch 87/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0118
```



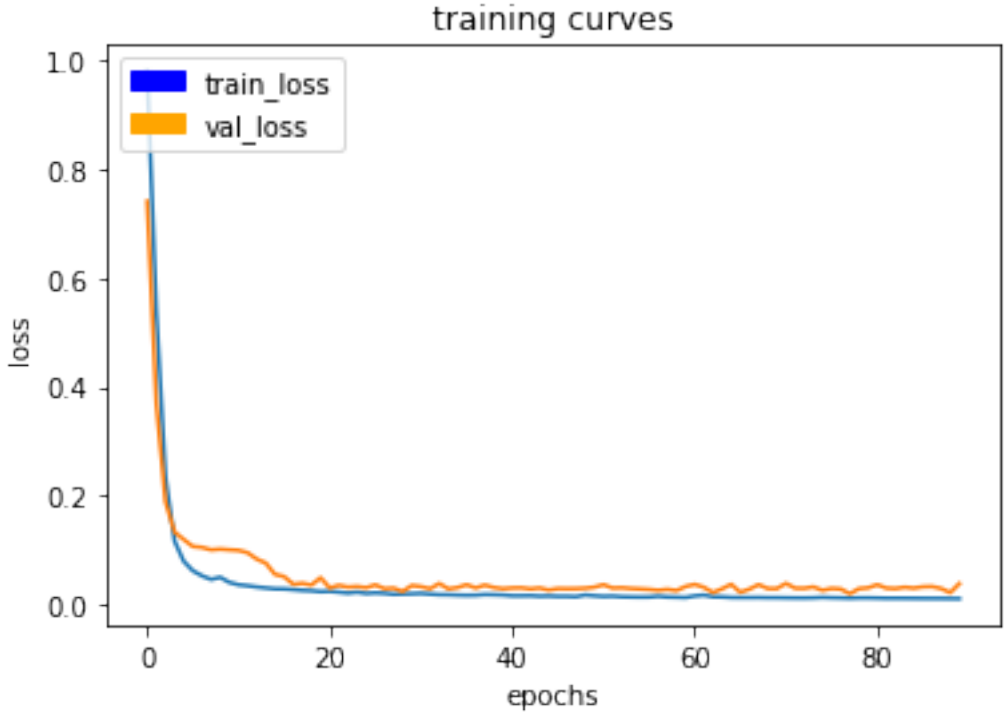
```
41/41 [==============================] - 58s - loss: 0.0118 - val_loss: 0.0336
Epoch 88/200
40/41 [============================>.] - ETA: 1s - loss: 0.0117
```



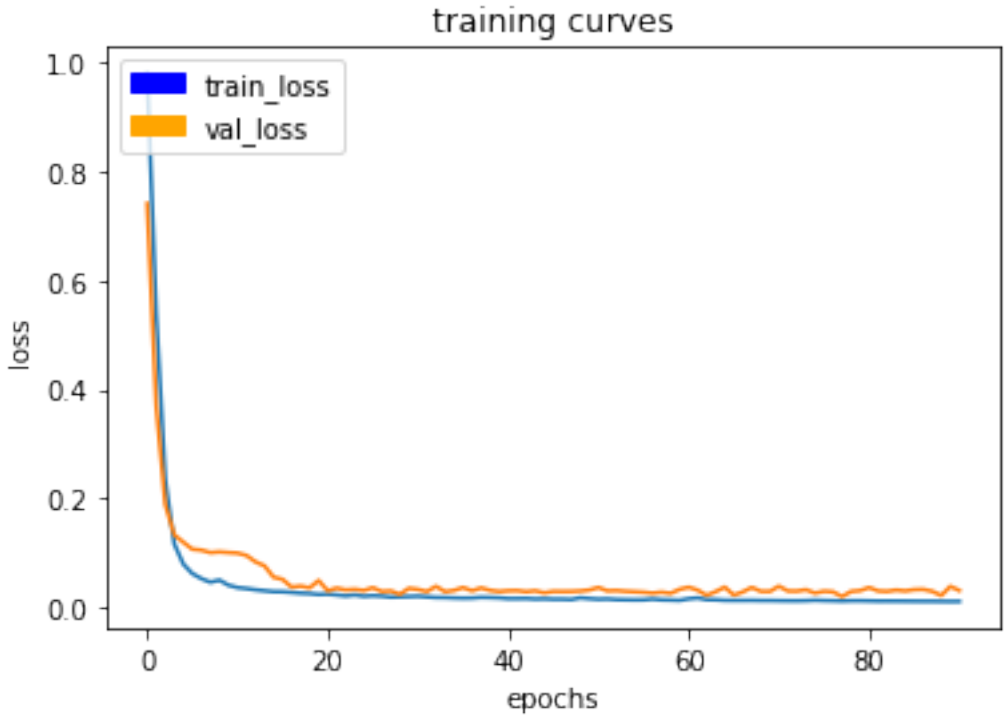

```
41/41 [==============================] - 58s - loss: 0.0117 - val_loss: 0.0301
Epoch 89/200
40/41 [============================>.] - ETA: 1s - loss: 0.0115
```



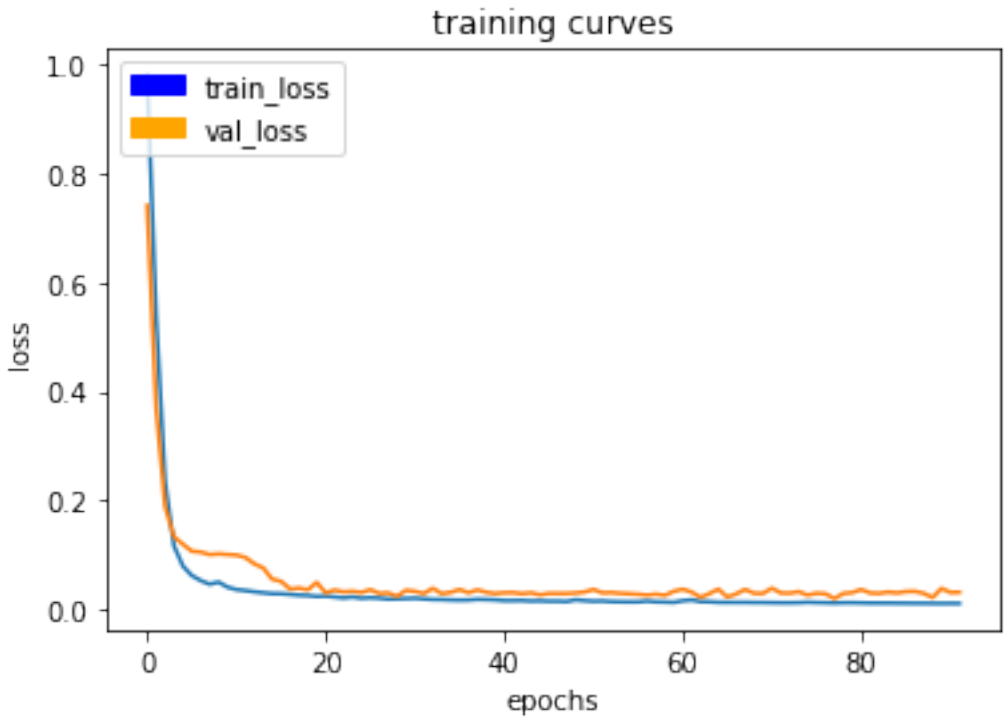

```
41/41 [==============================] - 57s - loss: 0.0115 - val_loss: 0.0224
Epoch 90/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0115
```



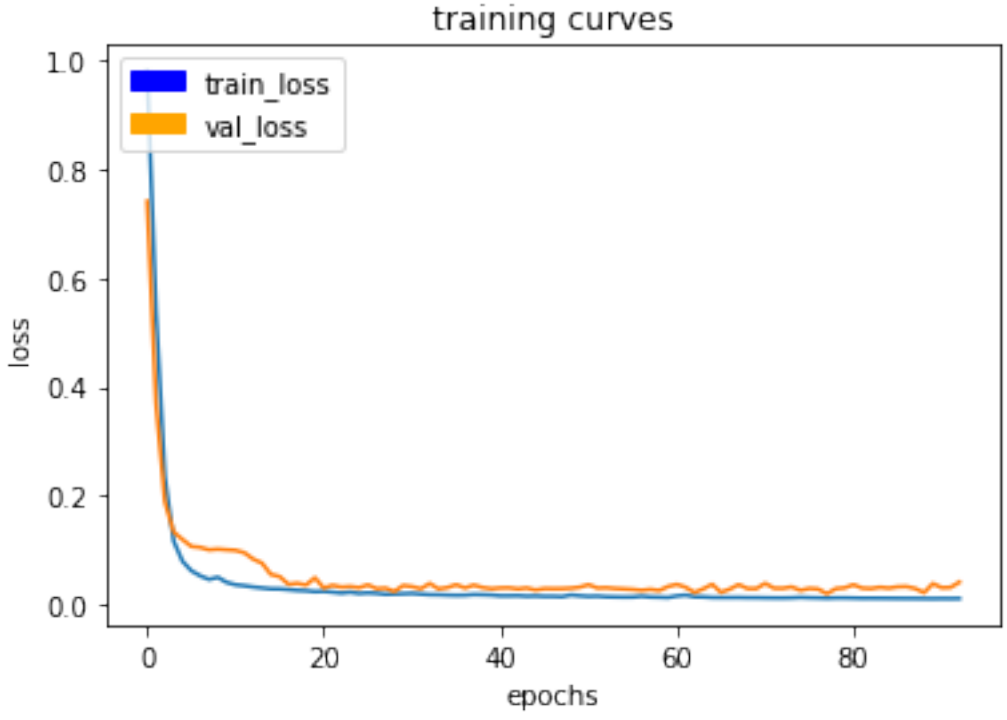
```
41/41 [==============================] - 57s - loss: 0.0114 - val_loss: 0.0391
Epoch 91/200
40/41 [============================>.] - ETA: 1s - loss: 0.0116
```



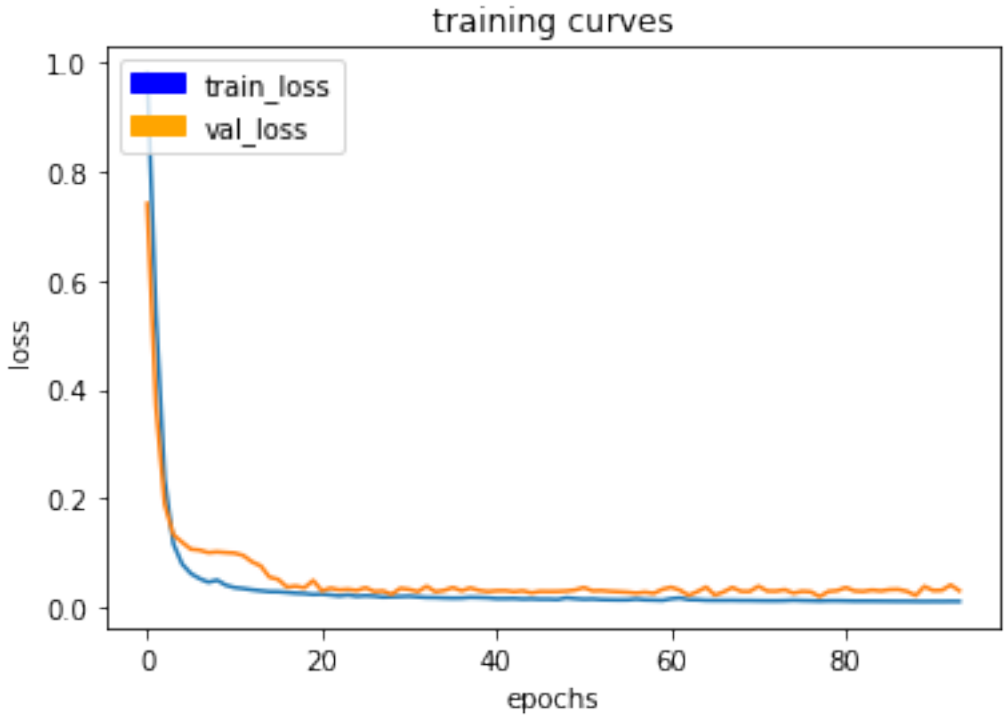

```
41/41 [==============================] - 57s - loss: 0.0116 - val_loss: 0.0315
Epoch 92/200
40/41 [============================>.] - ETA: 1s - loss: 0.0114
```



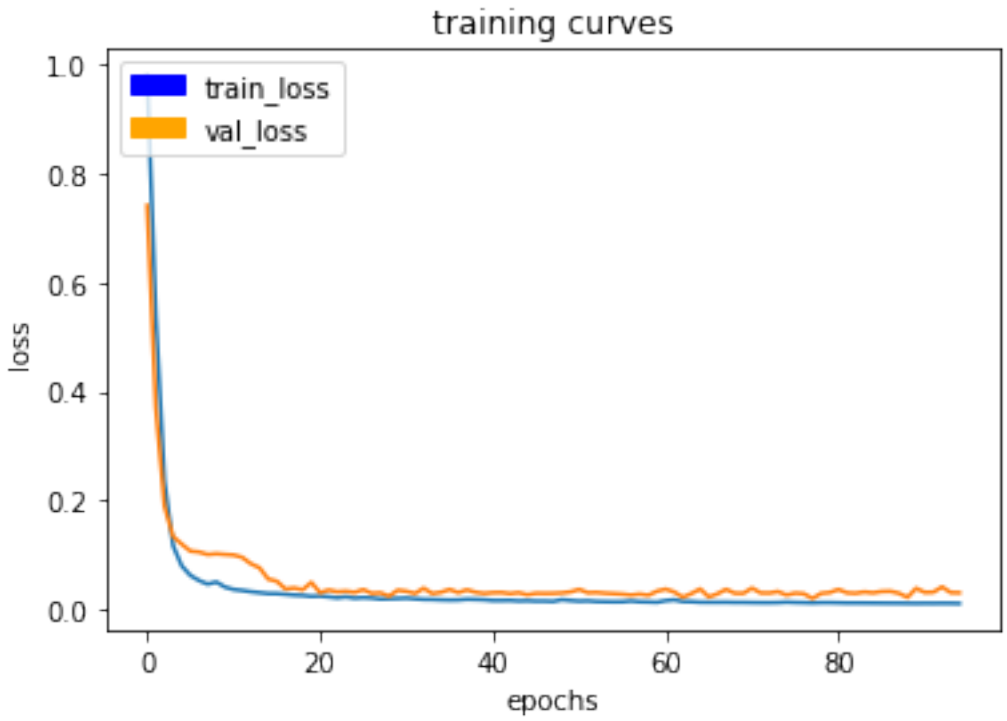

```
41/41 [==============================] - 57s - loss: 0.0114 - val_loss: 0.0320
Epoch 93/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0116
```



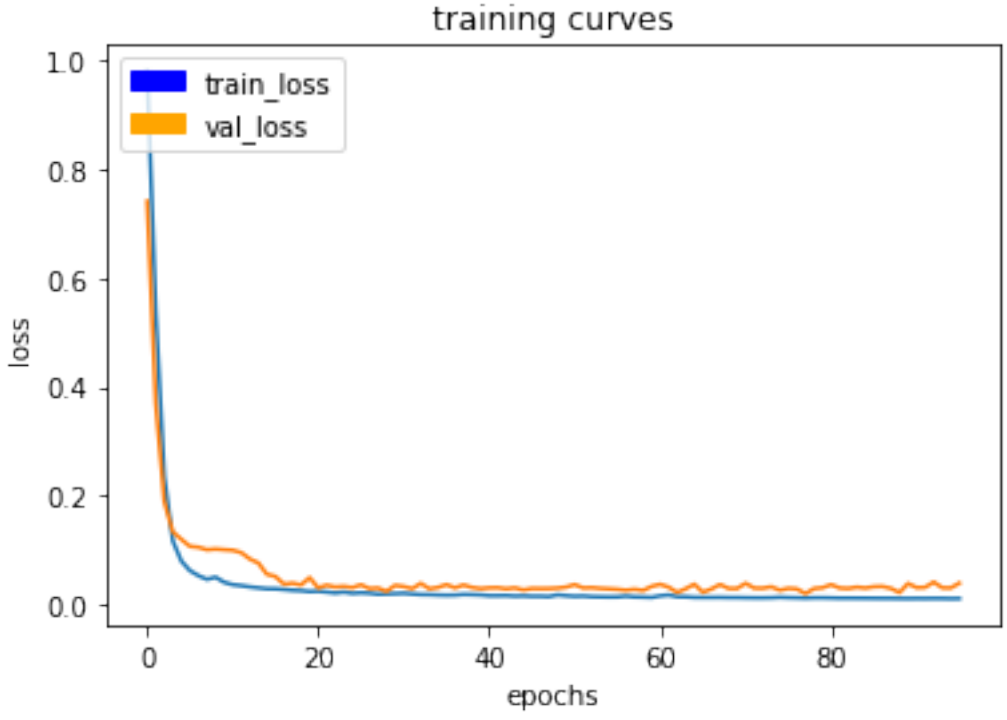
```
41/41 [==============================] - 57s - loss: 0.0116 - val_loss: 0.0417
Epoch 94/200
40/41 [============================>.] - ETA: 1s - loss: 0.0114
```



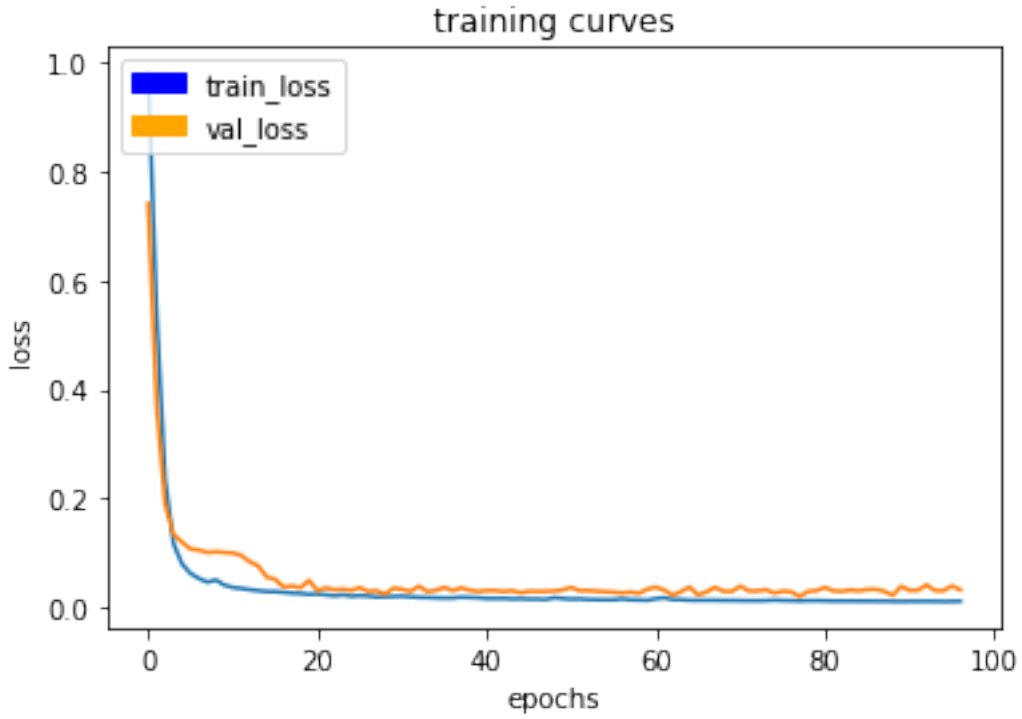

```
41/41 [==============================] - 57s - loss: 0.0115 - val_loss: 0.0312
Epoch 95/200
40/41 [============================>.] - ETA: 1s - loss: 0.0112
```



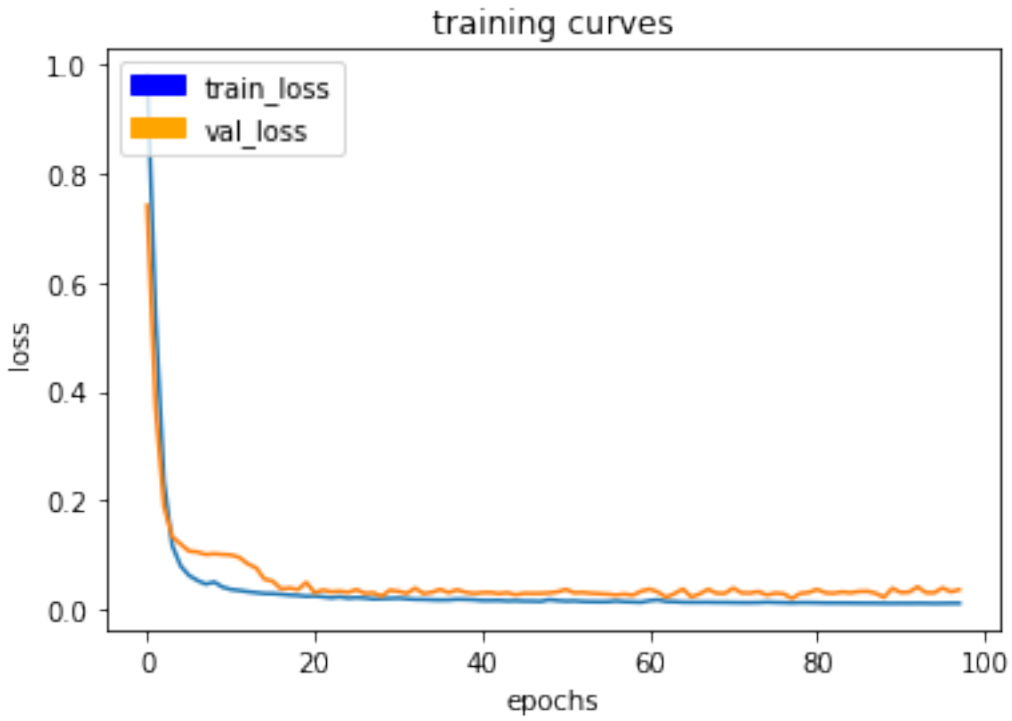

```
41/41 [==============================] - 57s - loss: 0.0112 - val_loss: 0.0309
Epoch 96/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0114
```



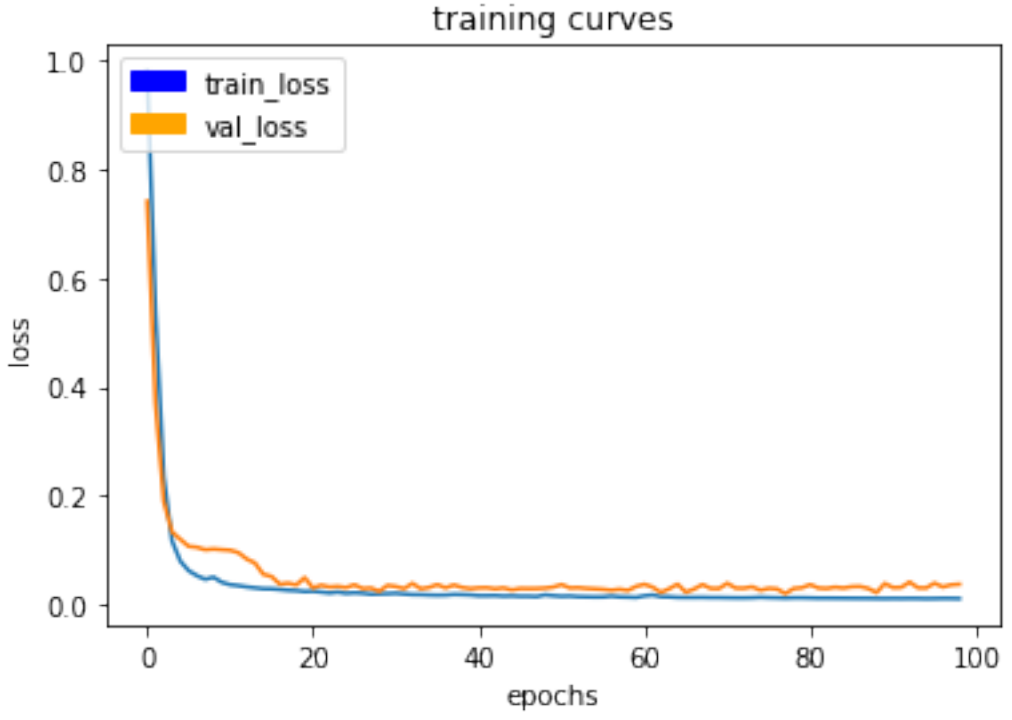
```
41/41 [==============================] - 57s - loss: 0.0114 - val_loss: 0.0398
Epoch 97/200
40/41 [============================>.] - ETA: 1s - loss: 0.0117
```



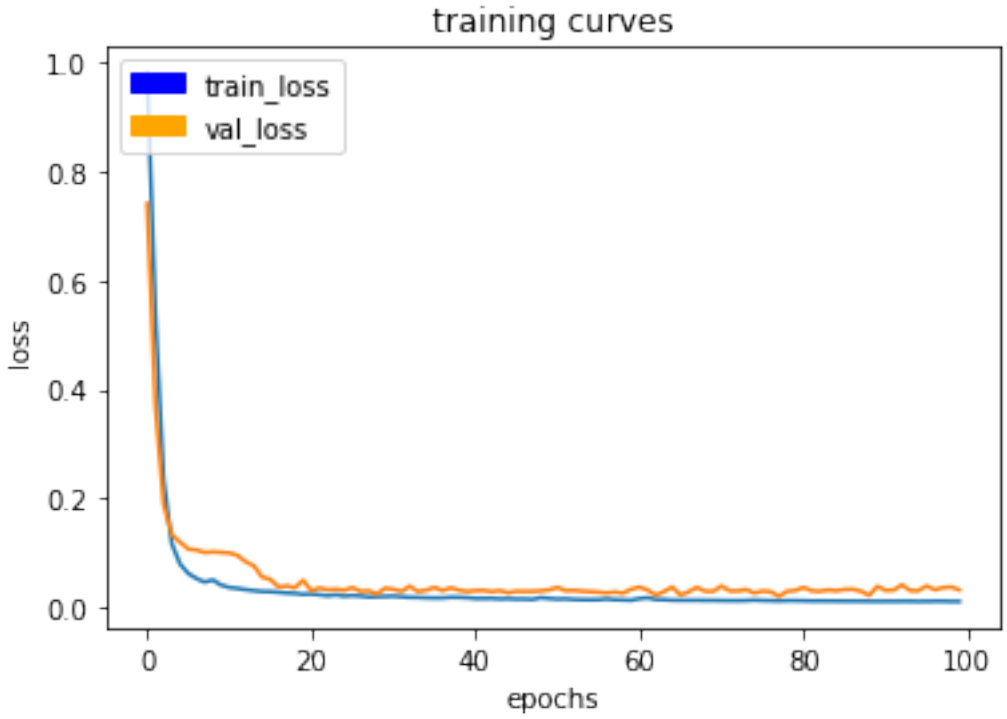

```
41/41 [==============================] - 57s - loss: 0.0117 - val_loss: 0.0326
Epoch 98/200
40/41 [============================>.] - ETA: 1s - loss: 0.0116
```



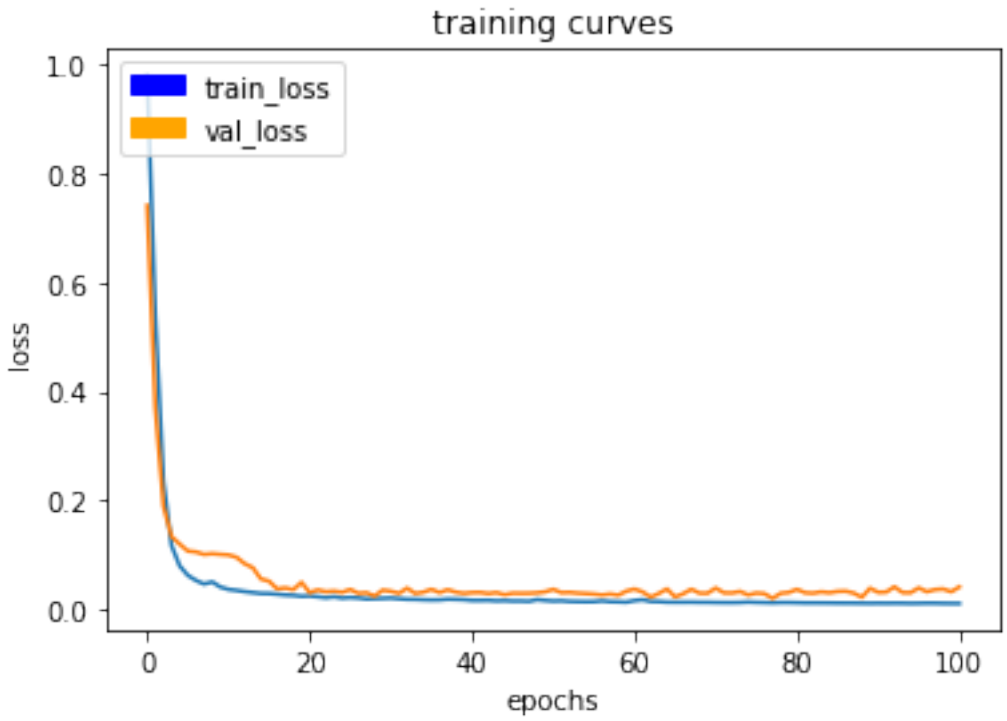

```
41/41 [==============================] - 57s - loss: 0.0116 - val_loss: 0.0366
Epoch 99/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0113
```



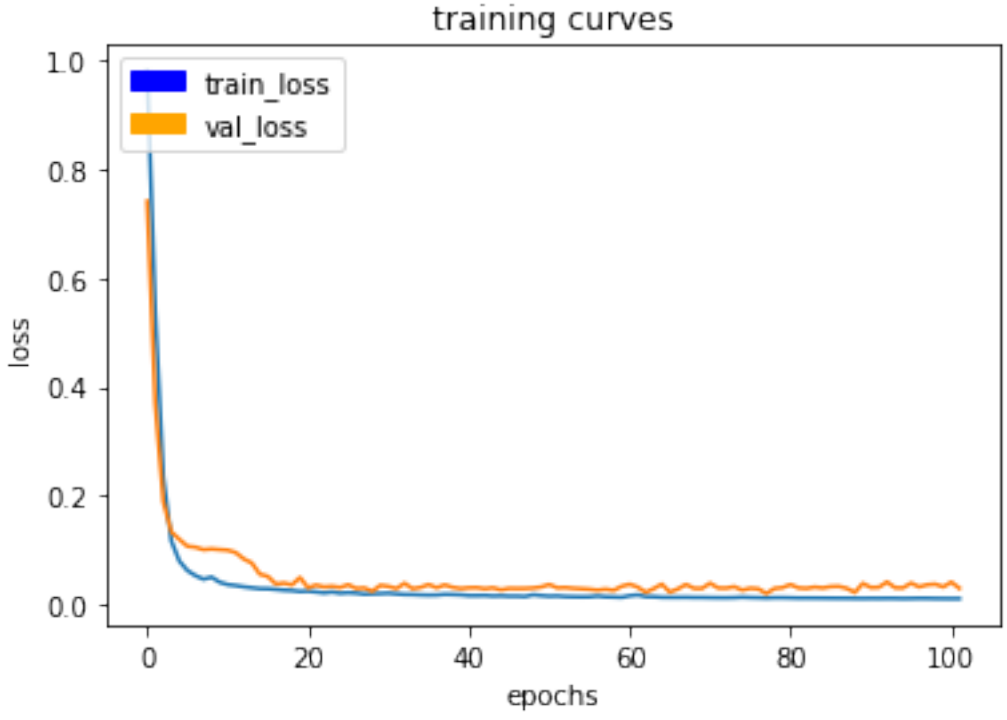
```
41/41 [==============================] - 57s - loss: 0.0113 - val_loss: 0.0377
Epoch 100/200
40/41 [============================>.] - ETA: 1s - loss: 0.0112
```



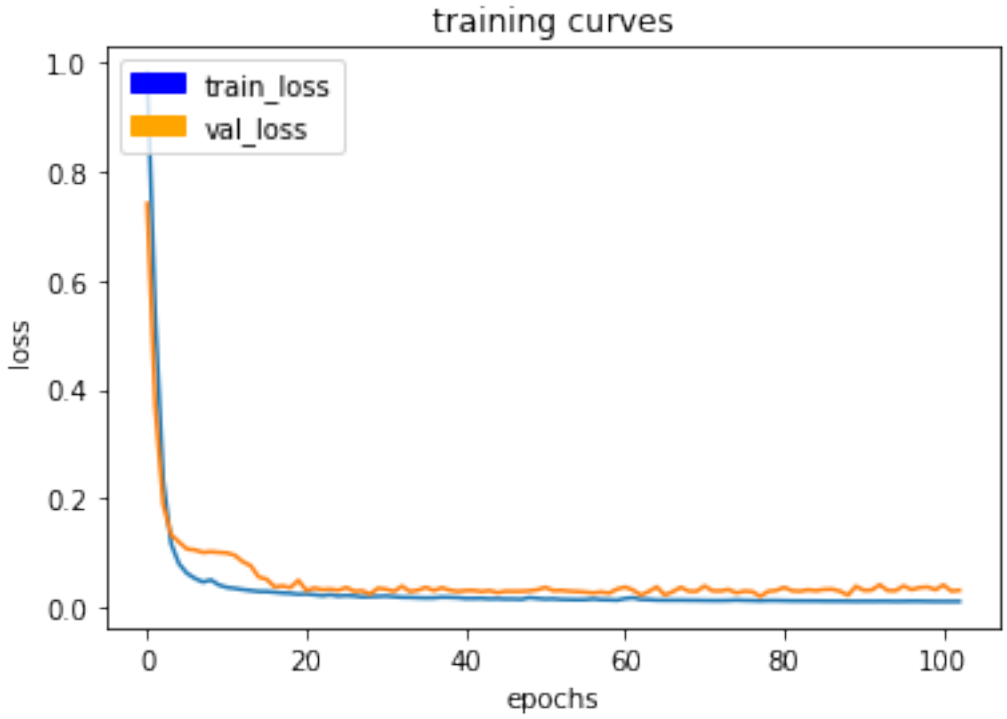

```
41/41 [==============================] - 57s - loss: 0.0112 - val_loss: 0.0326
Epoch 101/200
40/41 [============================>.] - ETA: 1s - loss: 0.0111
```



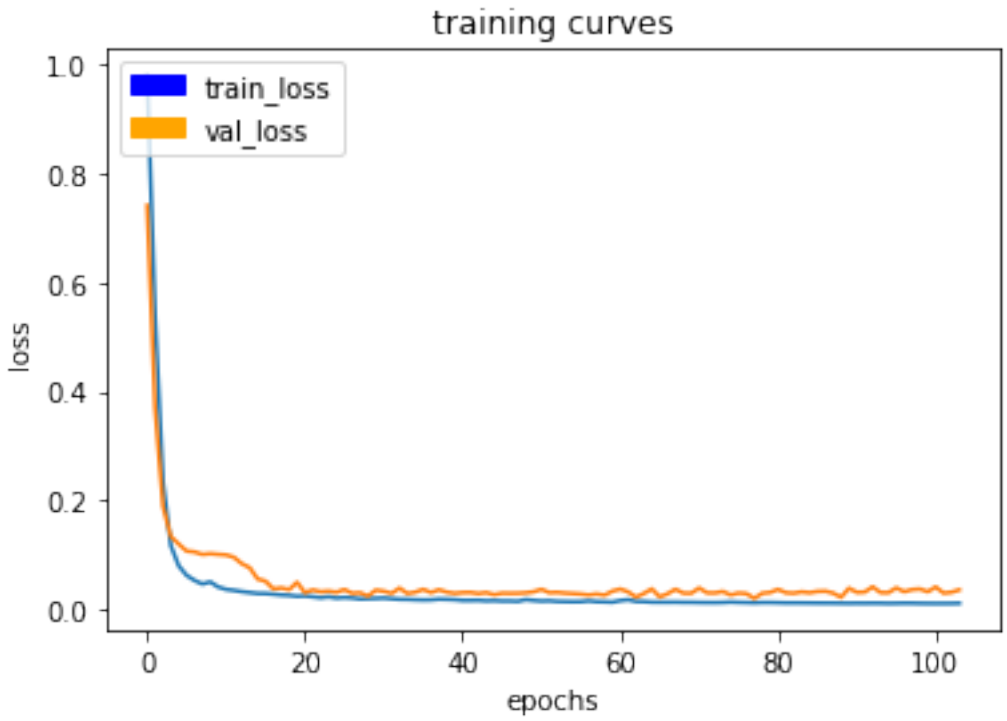

```
41/41 [==============================] - 58s - loss: 0.0111 - val_loss: 0.0414
Epoch 102/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0111
```



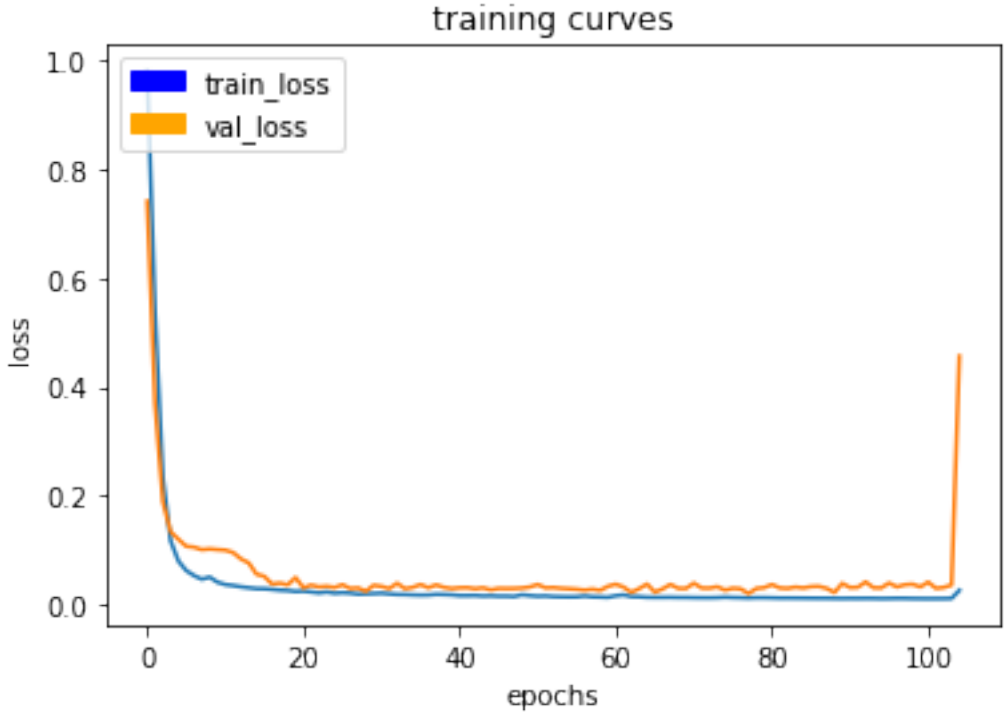
```
41/41 [==============================] - 57s - loss: 0.0111 - val_loss: 0.0301
Epoch 103/200
40/41 [============================>.] - ETA: 1s - loss: 0.0112
```



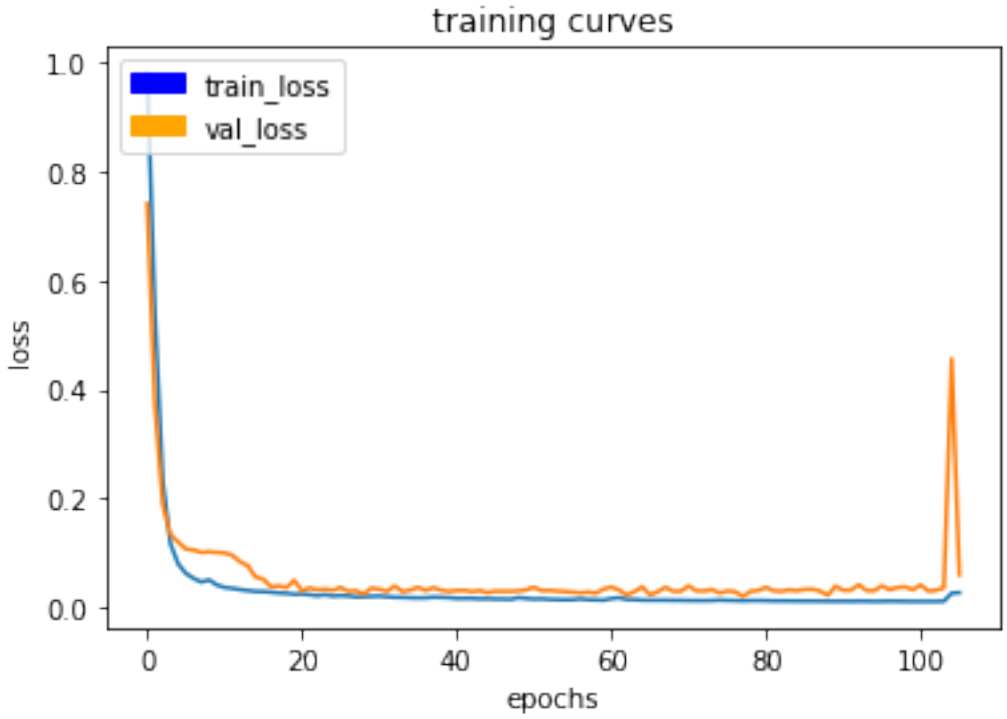

```
41/41 [==============================] - 57s - loss: 0.0112 - val_loss: 0.0316
Epoch 104/200
40/41 [============================>.] - ETA: 1s - loss: 0.0115
```



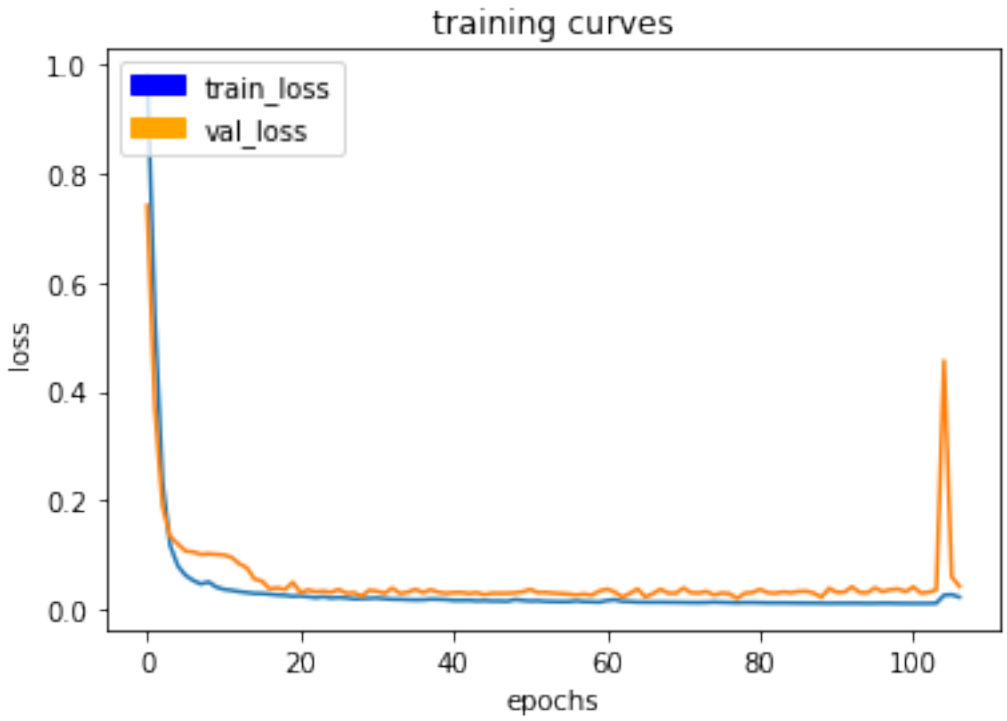

```
41/41 [==============================] - 57s - loss: 0.0115 - val_loss: 0.0361
Epoch 105/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0263
```



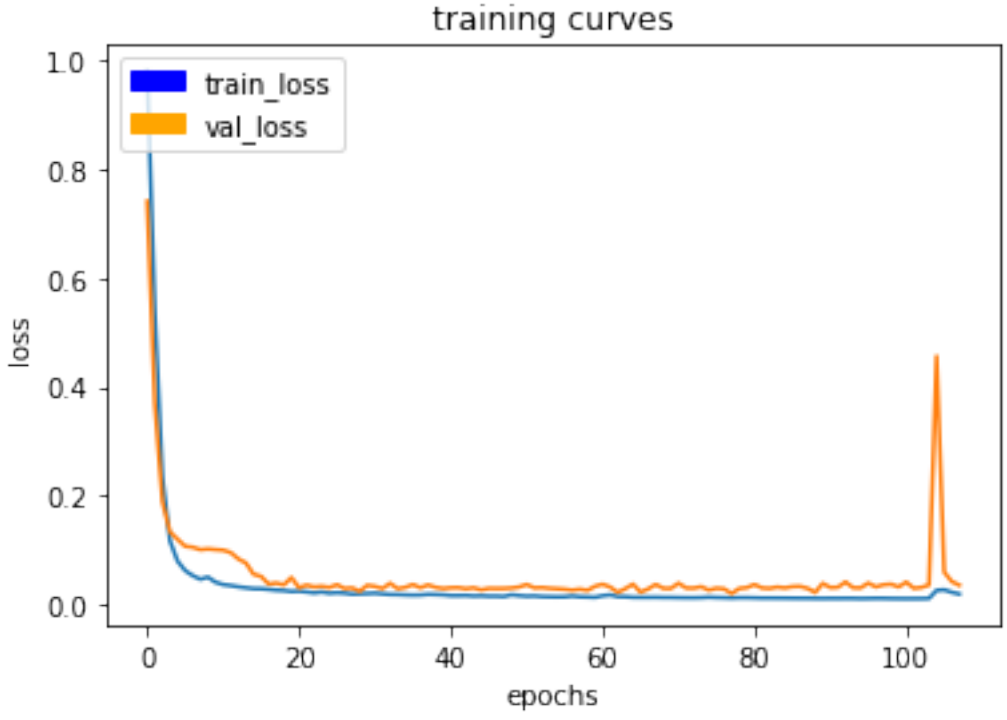
```
41/41 [==============================] - 57s - loss: 0.0264 - val_loss: 0.4565
Epoch 106/200
40/41 [============================>.] - ETA: 1s - loss: 0.0275
```



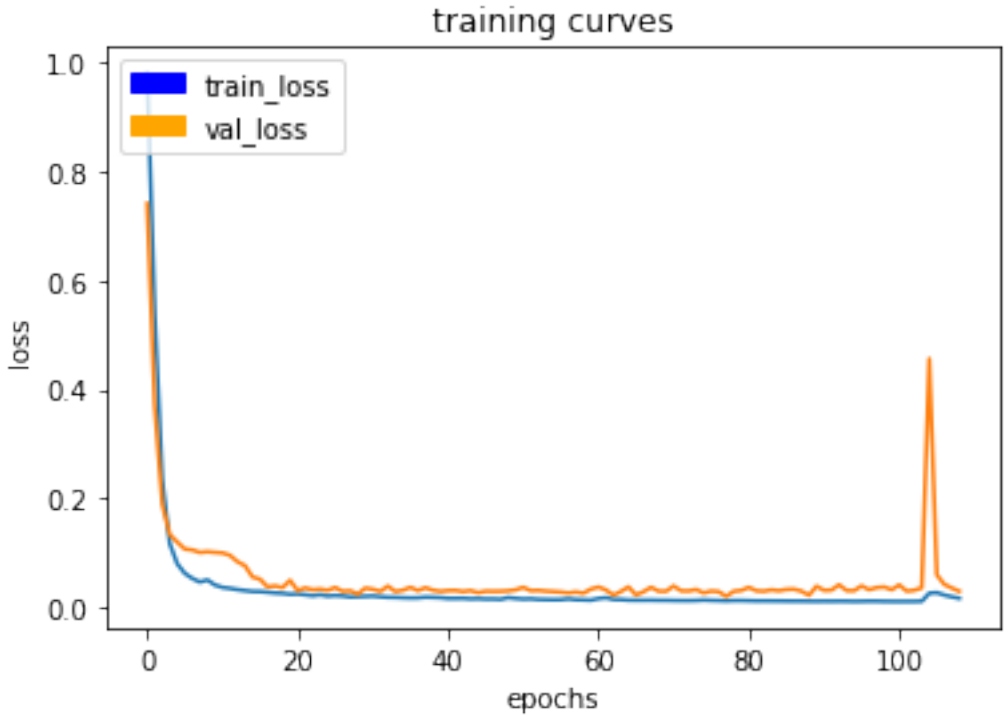

```
41/41 [==============================] - 57s - loss: 0.0274 - val_loss: 0.0599
Epoch 107/200
40/41 [============================>.] - ETA: 1s - loss: 0.0228
```



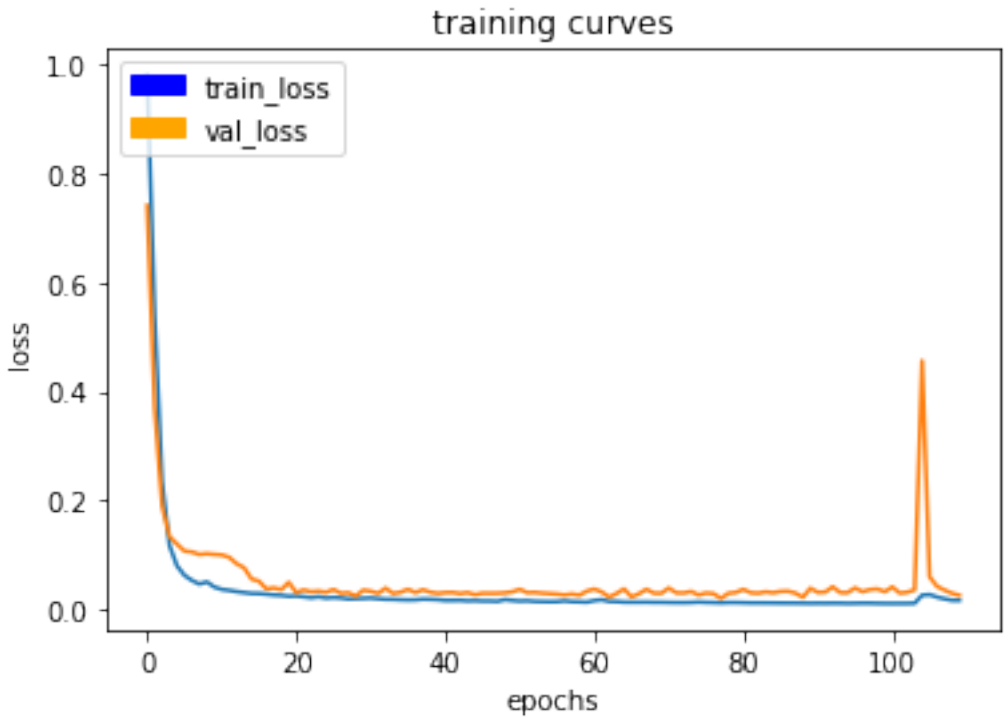

```
41/41 [==============================] - 57s - loss: 0.0227 - val_loss: 0.0425
Epoch 108/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0196
```



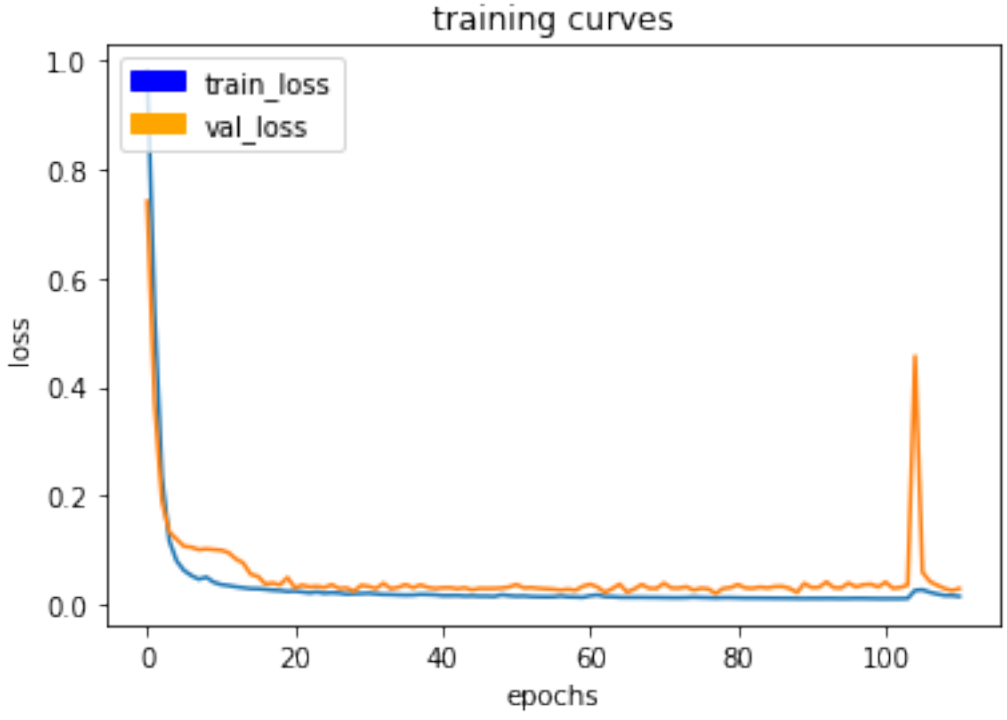
```
41/41 [==============================] - 58s - loss: 0.0196 - val_loss: 0.0357
Epoch 109/200
40/41 [============================>.] - ETA: 1s - loss: 0.0169
```



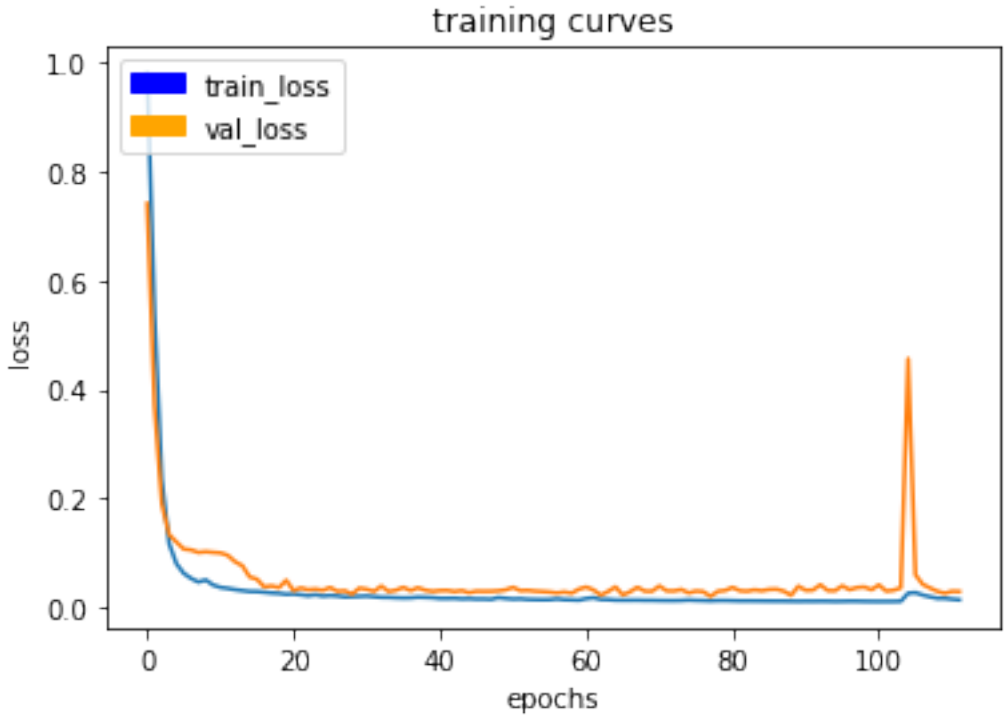

```
41/41 [==============================] - 57s - loss: 0.0169 - val_loss: 0.0297
Epoch 110/200
40/41 [============================>.] - ETA: 1s - loss: 0.0169
```



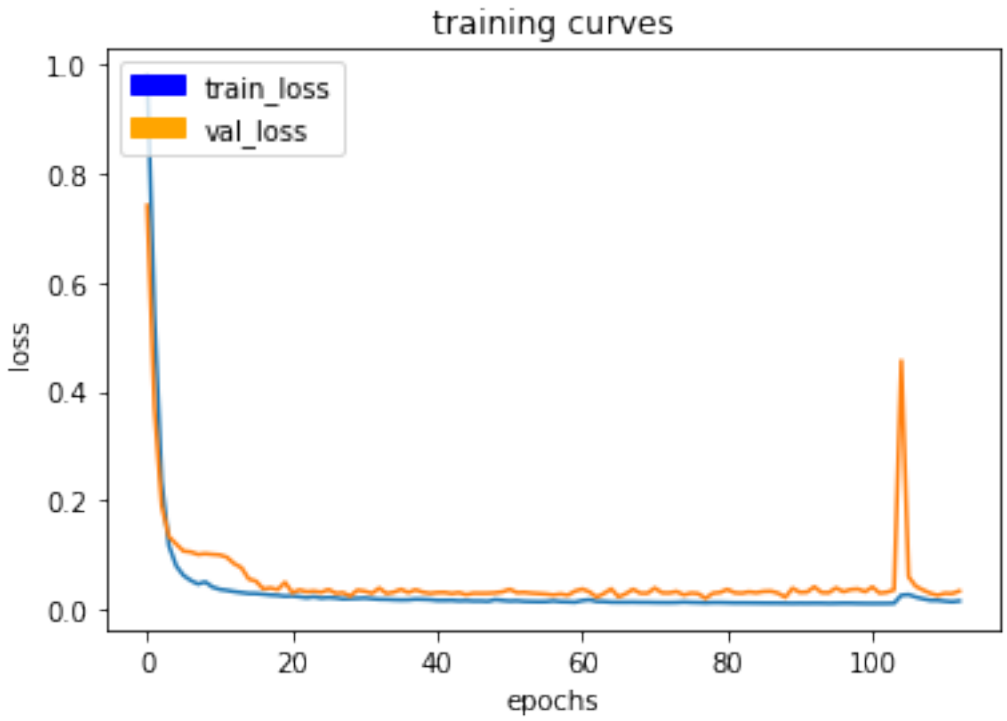

```
41/41 [==============================] - 57s - loss: 0.0169 - val_loss: 0.0260
Epoch 111/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0154
```



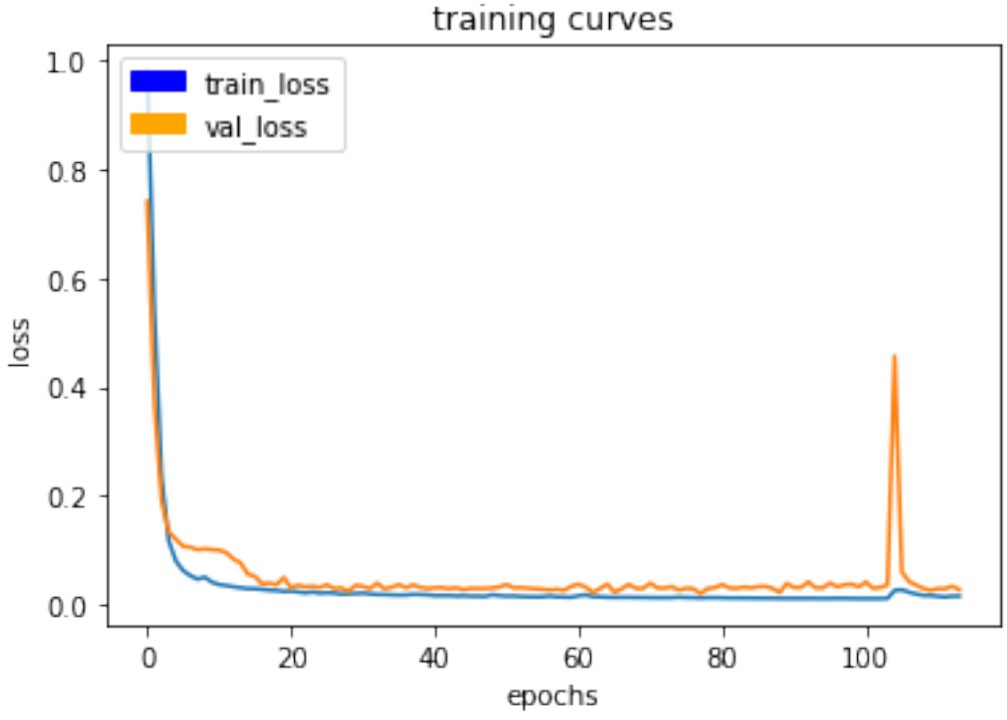
```
41/41 [==============================] - 57s - loss: 0.0153 - val_loss: 0.0297
Epoch 112/200
40/41 [============================>.] - ETA: 1s - loss: 0.0142
```



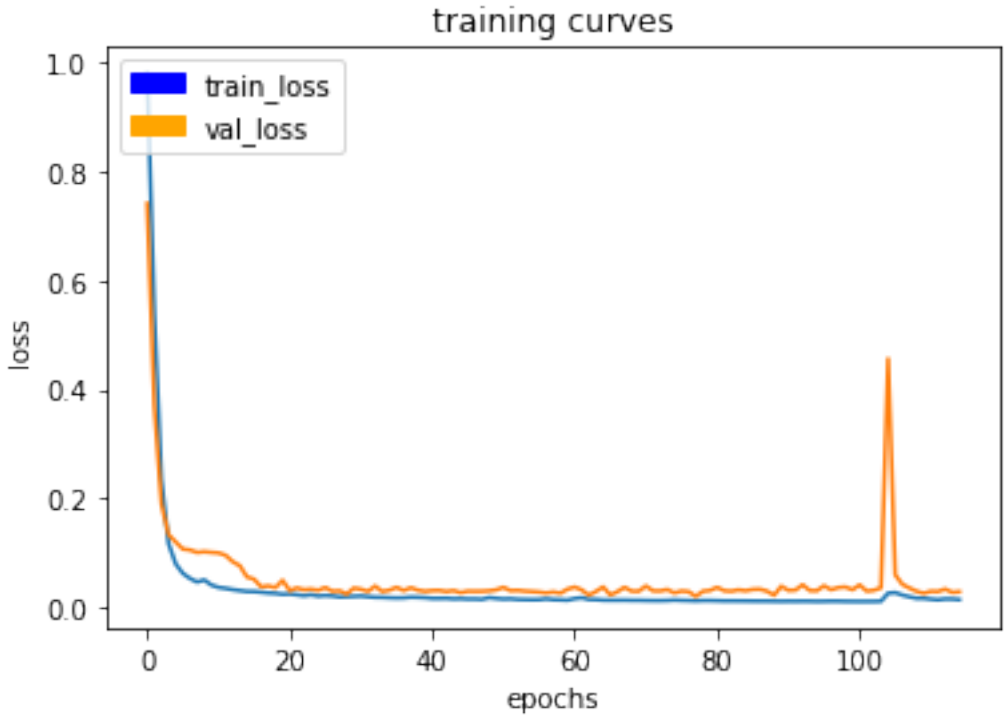

```
41/41 [==============================] - 57s - loss: 0.0142 - val_loss: 0.0292
Epoch 113/200
40/41 [============================>.] - ETA: 1s - loss: 0.0156
```



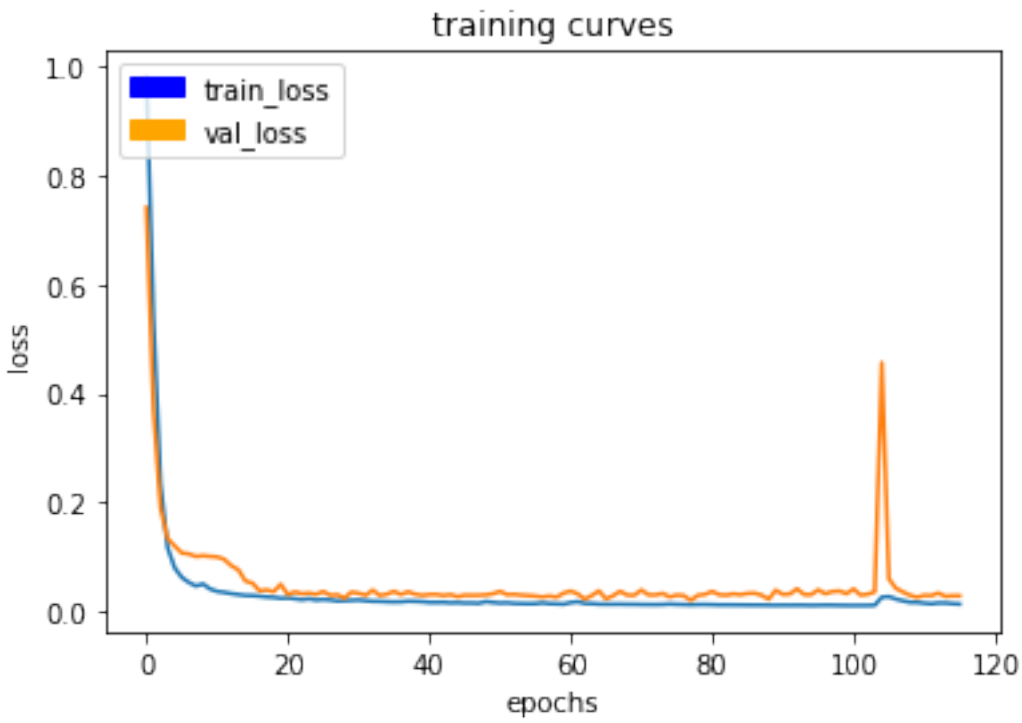

```
41/41 [==============================] - 57s - loss: 0.0156 - val_loss: 0.0338
Epoch 114/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0156
```



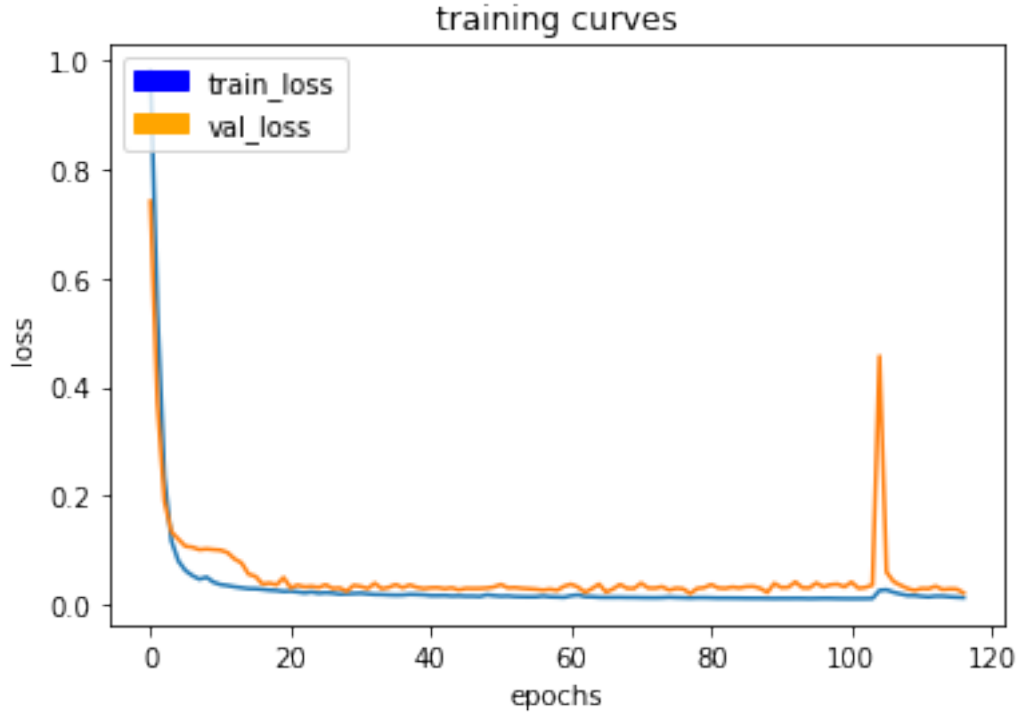
```
41/41 [==============================] - 57s - loss: 0.0155 - val_loss: 0.0277
Epoch 115/200
40/41 [============================>.] - ETA: 1s - loss: 0.0145
```



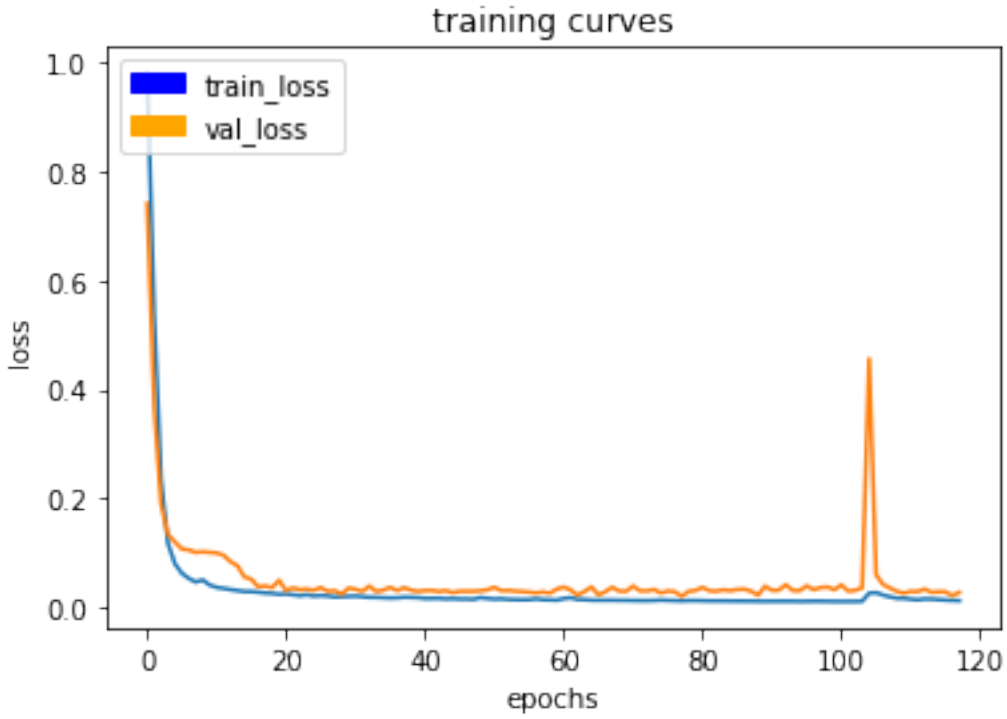

```
41/41 [==============================] - 57s - loss: 0.0145 - val_loss: 0.0290
Epoch 116/200
40/41 [============================>.] - ETA: 1s - loss: 0.0138
```



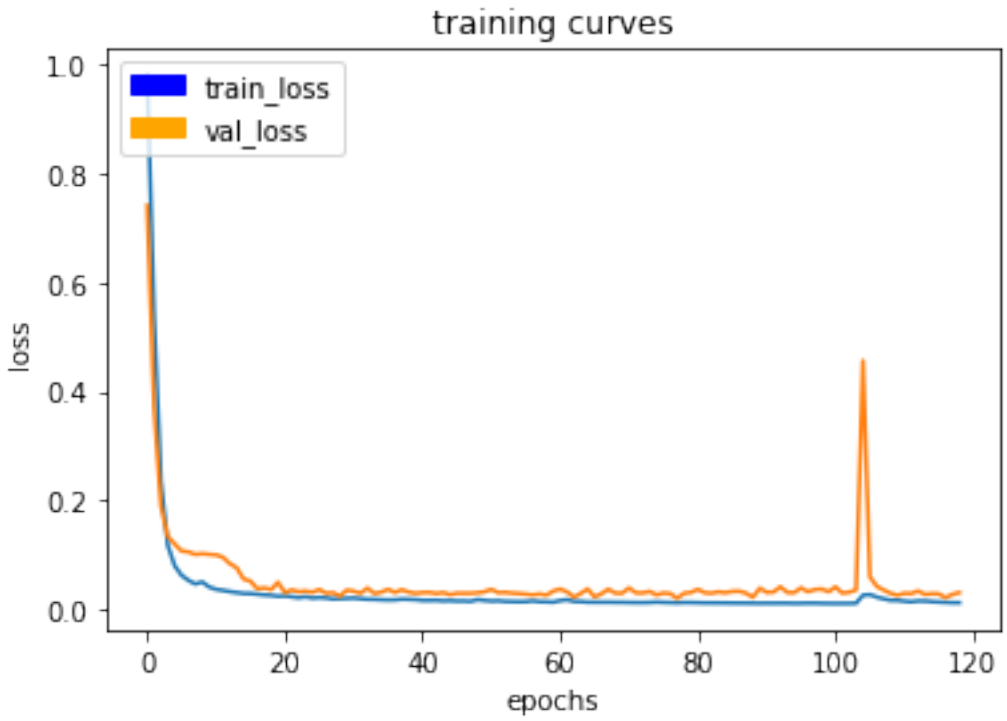

```
41/41 [==============================] - 56s - loss: 0.0137 - val_loss: 0.0287
Epoch 117/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0130
```



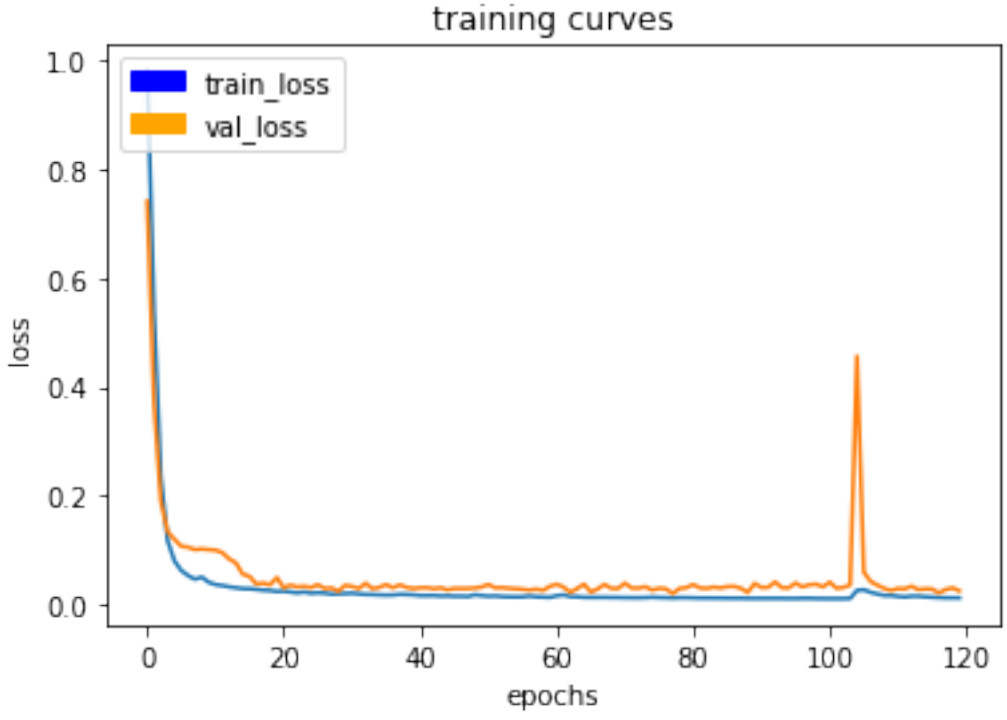
```
41/41 [==============================] - 57s - loss: 0.0130 - val_loss: 0.0216
Epoch 118/200
40/41 [============================>.] - ETA: 1s - loss: 0.0125
```



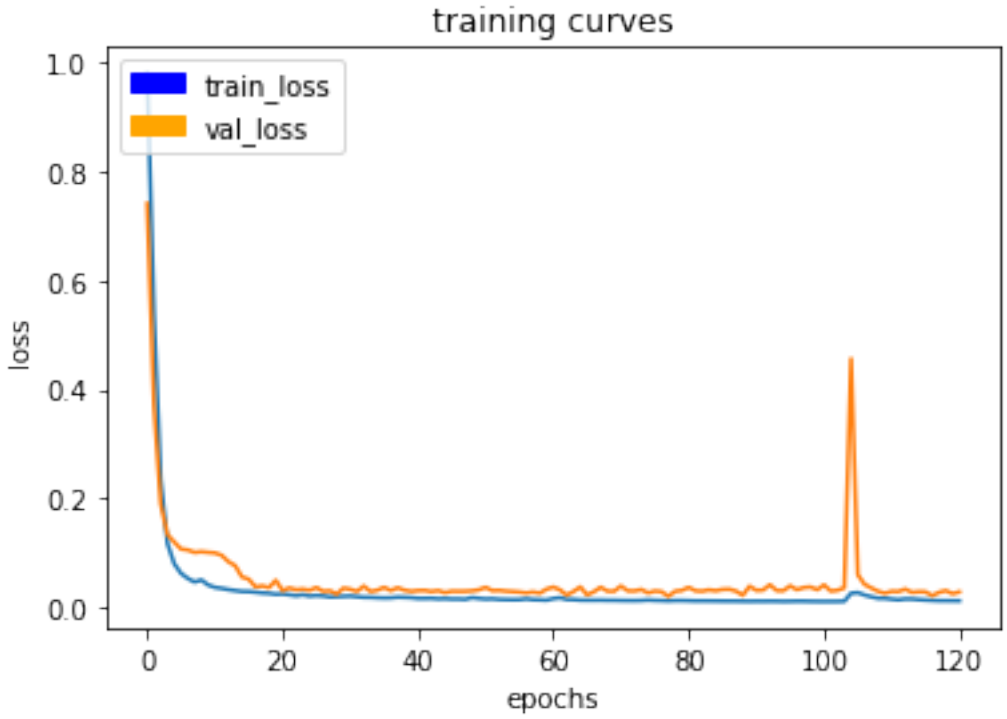

```
41/41 [==============================] - 57s - loss: 0.0125 - val_loss: 0.0278
Epoch 119/200
40/41 [============================>.] - ETA: 1s - loss: 0.0125
```



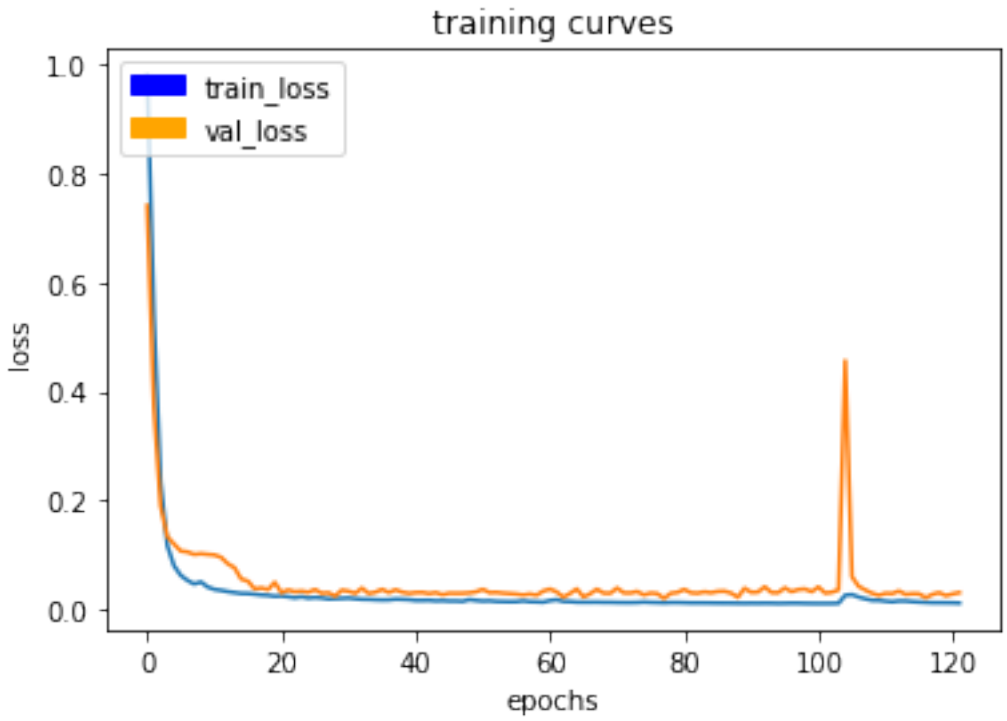

```
41/41 [==============================] - 58s - loss: 0.0125 - val_loss: 0.0309
Epoch 120/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0124
```



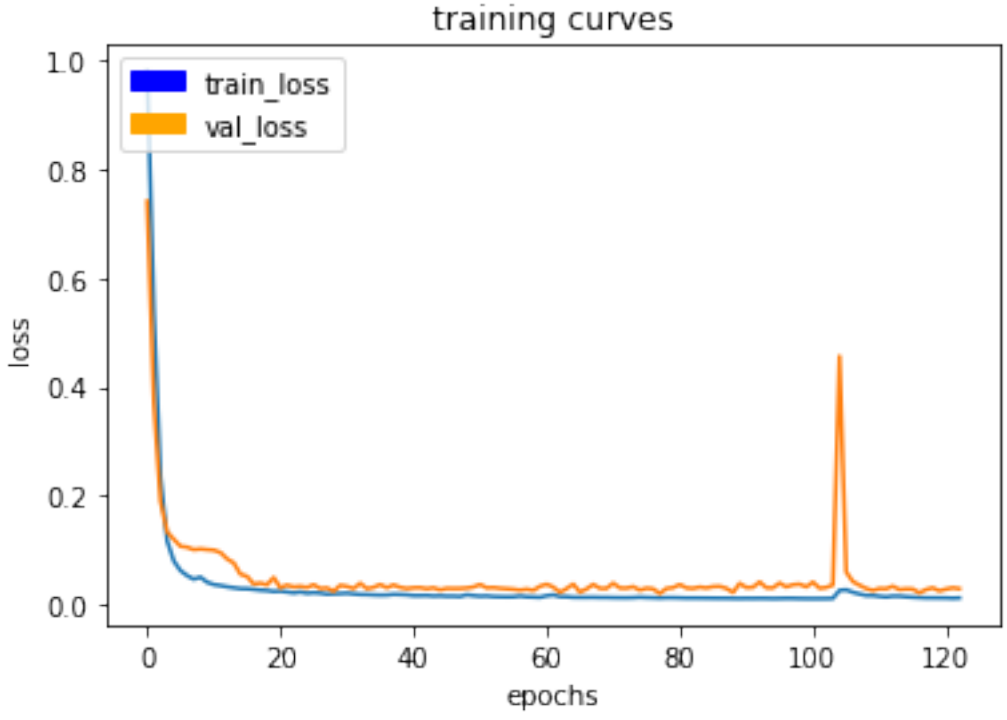
```
41/41 [==============================] - 58s - loss: 0.0125 - val_loss: 0.0253
Epoch 121/200
40/41 [============================>.] - ETA: 1s - loss: 0.0123
```



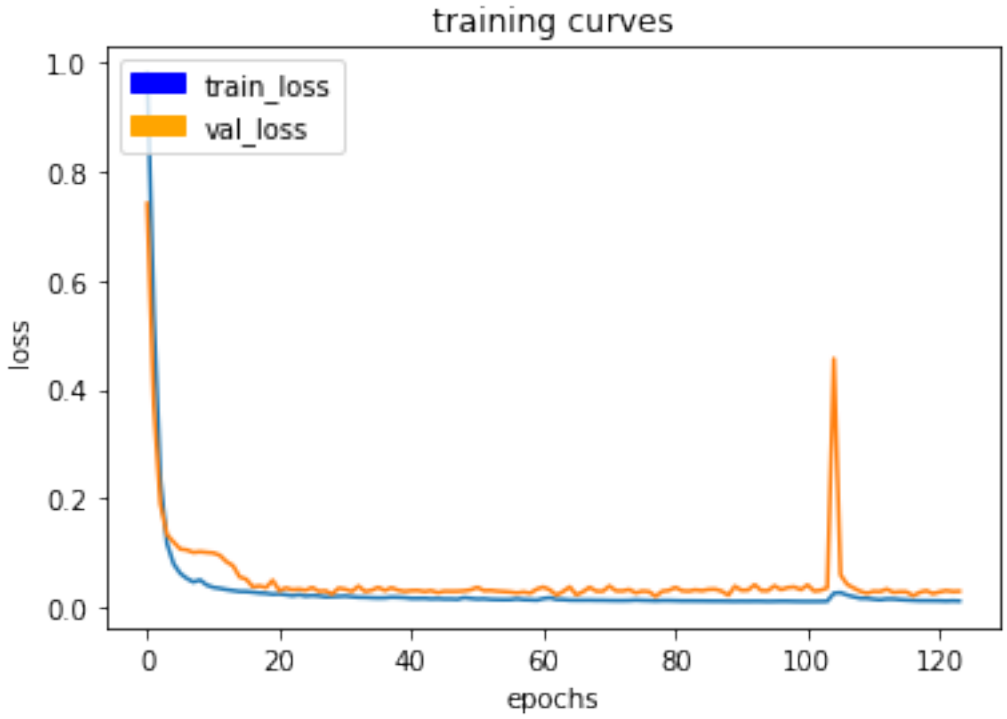

```
41/41 [==============================] - 57s - loss: 0.0123 - val_loss: 0.0286
Epoch 122/200
40/41 [============================>.] - ETA: 1s - loss: 0.0119
```



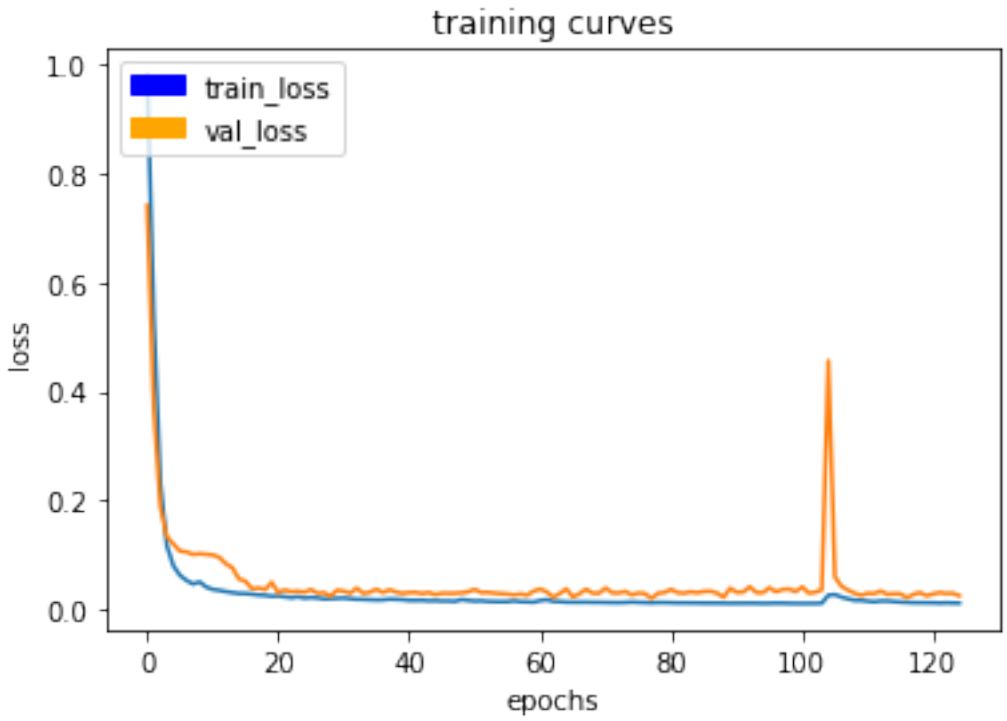

```
41/41 [==============================] - 58s - loss: 0.0118 - val_loss: 0.0310
Epoch 123/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0123
```



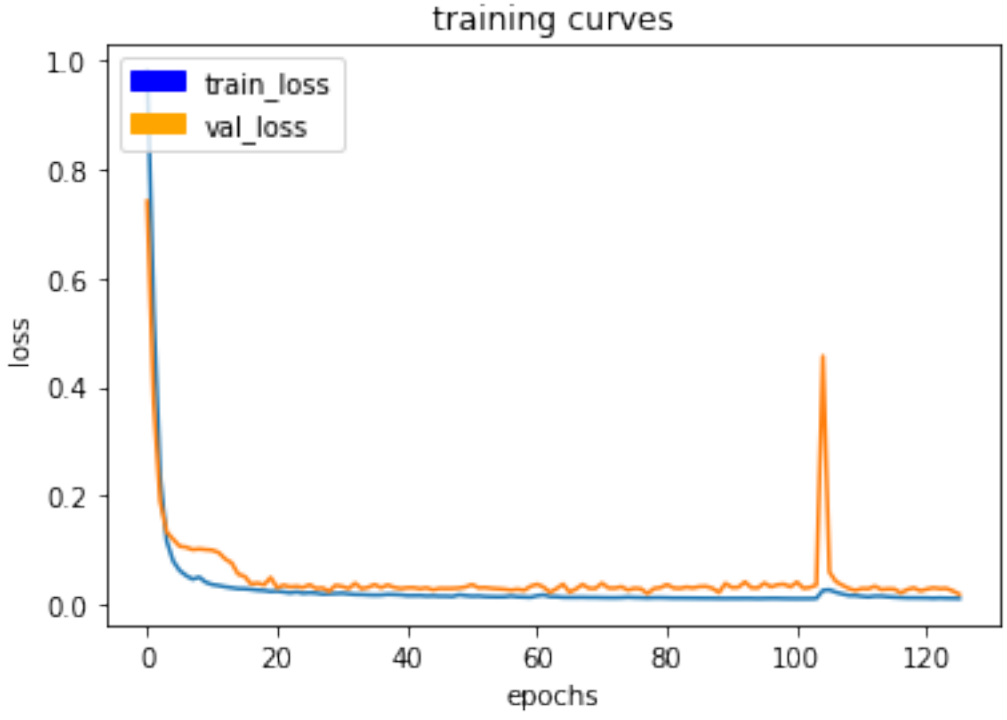
```
41/41 [==============================] - 58s - loss: 0.0123 - val_loss: 0.0294
Epoch 124/200
40/41 [============================>.] - ETA: 1s - loss: 0.0119
```



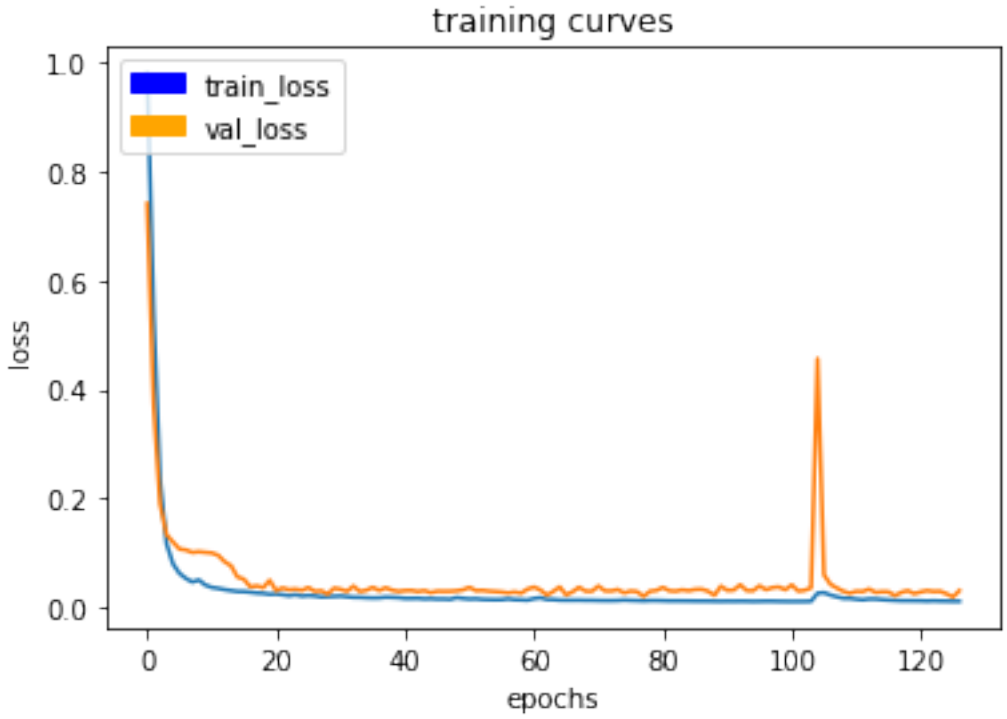

```
41/41 [==============================] - 57s - loss: 0.0119 - val_loss: 0.0299
Epoch 125/200
40/41 [============================>.] - ETA: 1s - loss: 0.0116
```



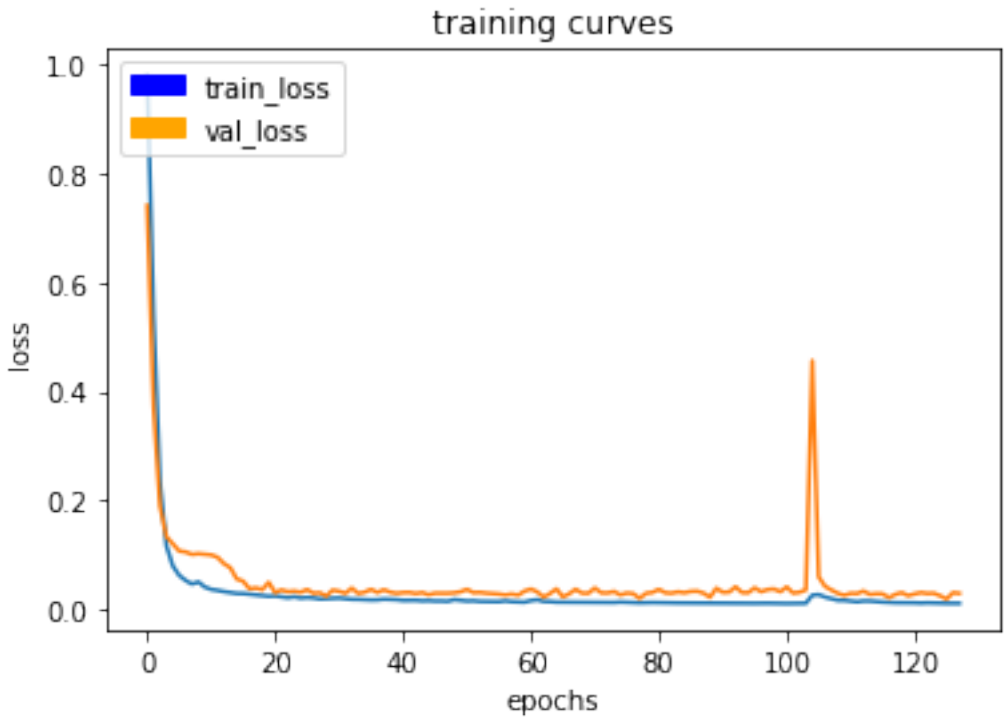

```
41/41 [==============================] - 58s - loss: 0.0117 - val_loss: 0.0252
Epoch 126/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0115
```



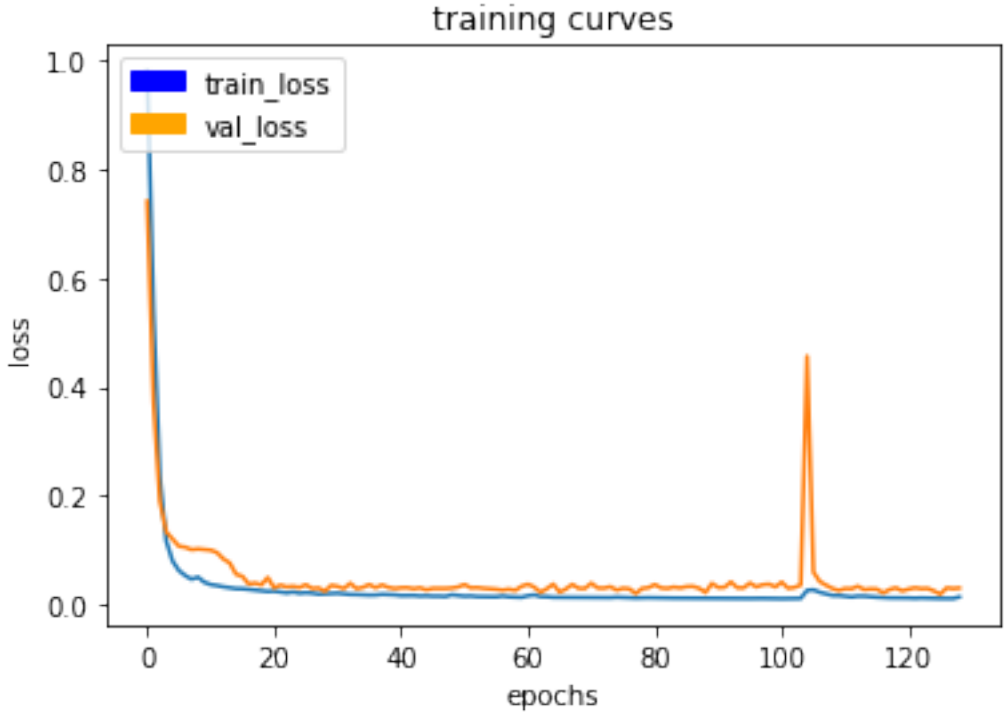
```
41/41 [==============================] - 57s - loss: 0.0115 - val_loss: 0.0191
Epoch 127/200
40/41 [============================>.] - ETA: 1s - loss: 0.0114
```



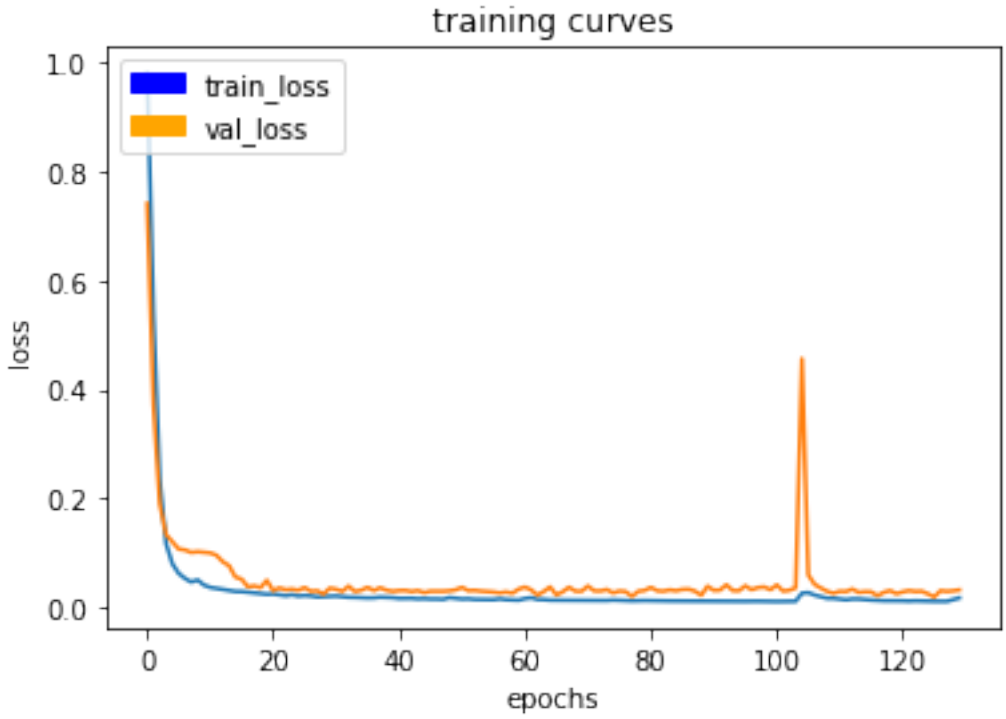

```
41/41 [==============================] - 57s - loss: 0.0114 - val_loss: 0.0309
Epoch 128/200
40/41 [============================>.] - ETA: 1s - loss: 0.0113
```



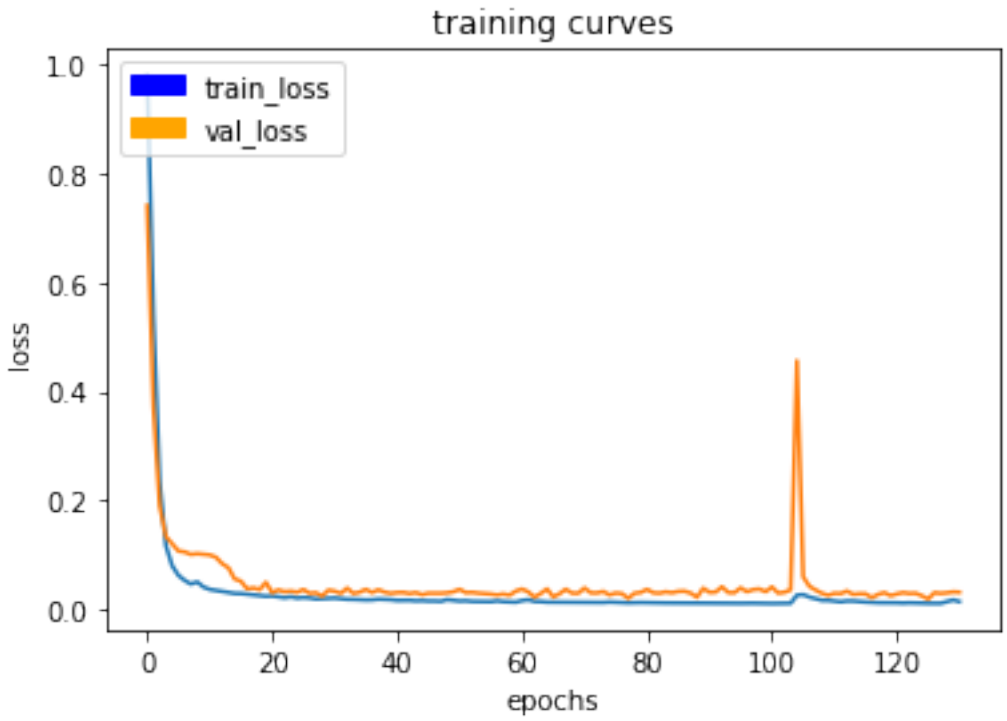

```
41/41 [==============================] - 58s - loss: 0.0113 - val_loss: 0.0296
Epoch 129/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0141
```



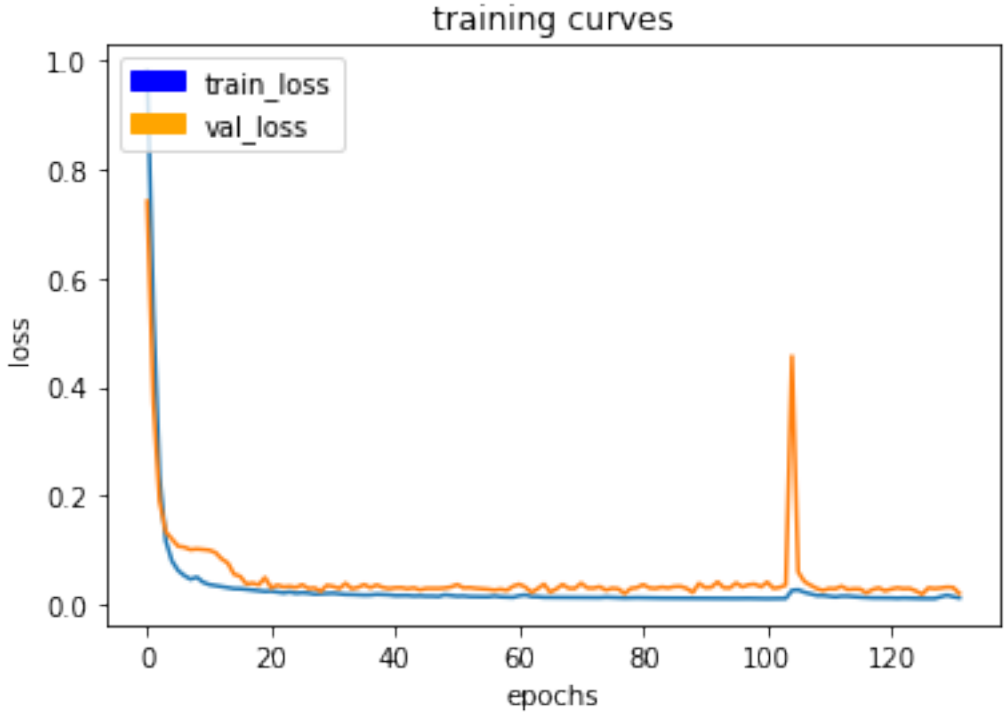
```
41/41 [==============================] - 58s - loss: 0.0141 - val_loss: 0.0306
Epoch 130/200
40/41 [============================>.] - ETA: 1s - loss: 0.0172
```



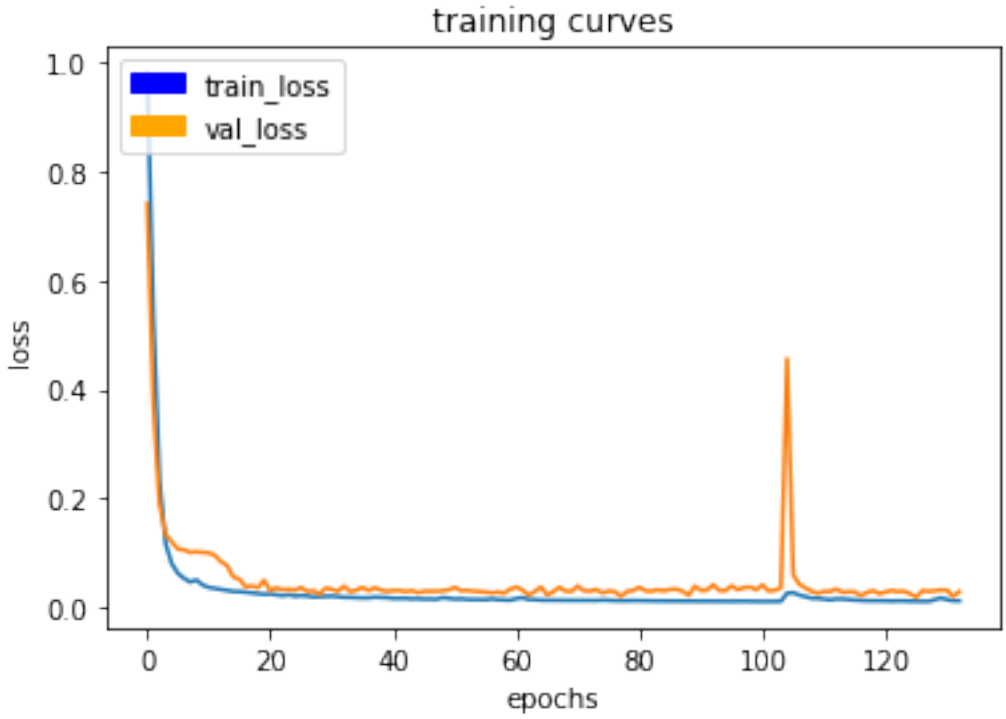

```
41/41 [==============================] - 58s - loss: 0.0175 - val_loss: 0.0323
Epoch 131/200
40/41 [============================>.] - ETA: 1s - loss: 0.0147
```



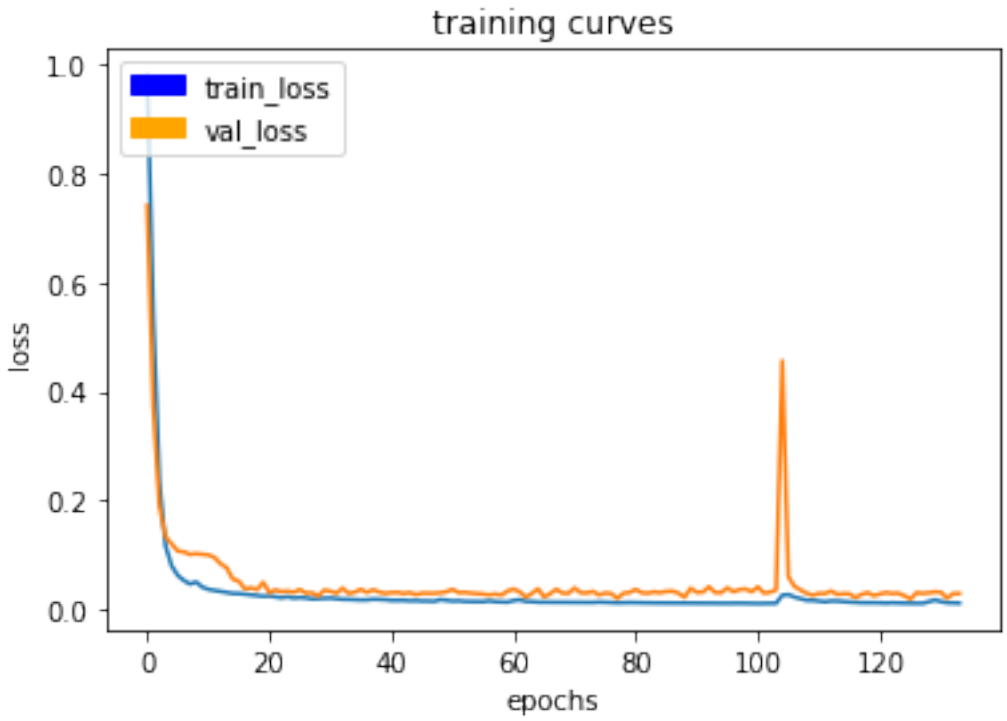

```
41/41 [==============================] - 57s - loss: 0.0147 - val_loss: 0.0316
Epoch 132/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0124
```



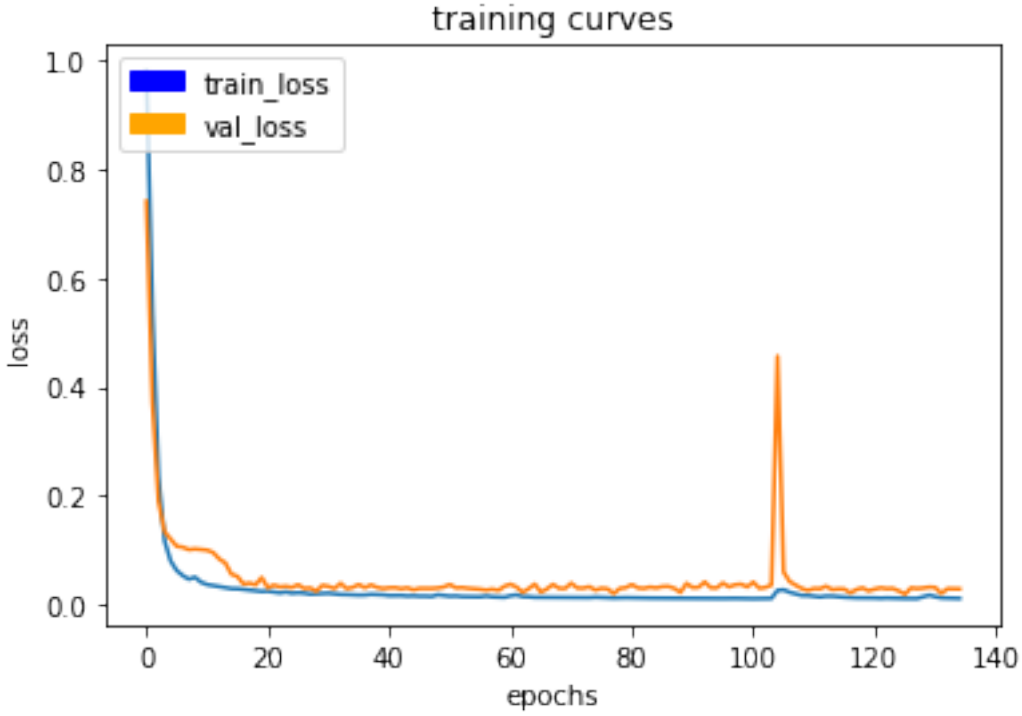
```
41/41 [==============================] - 57s - loss: 0.0124 - val_loss: 0.0207
Epoch 133/200
40/41 [============================>.] - ETA: 1s - loss: 0.0123
```



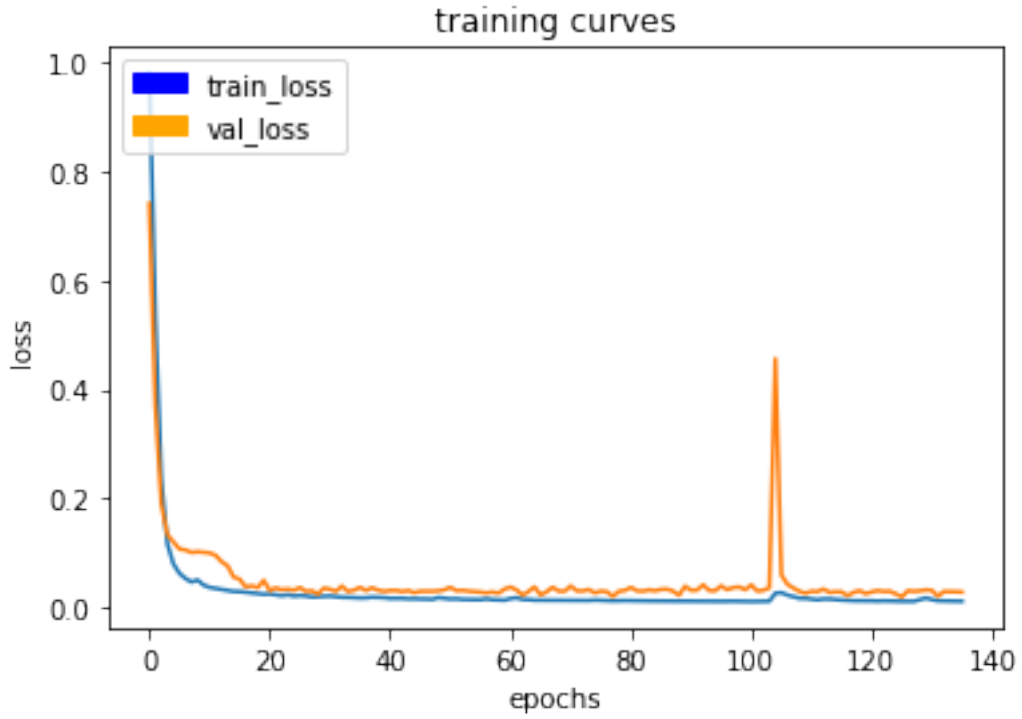

```
41/41 [==============================] - 58s - loss: 0.0123 - val_loss: 0.0294
Epoch 134/200
40/41 [============================>.] - ETA: 1s - loss: 0.0117
```



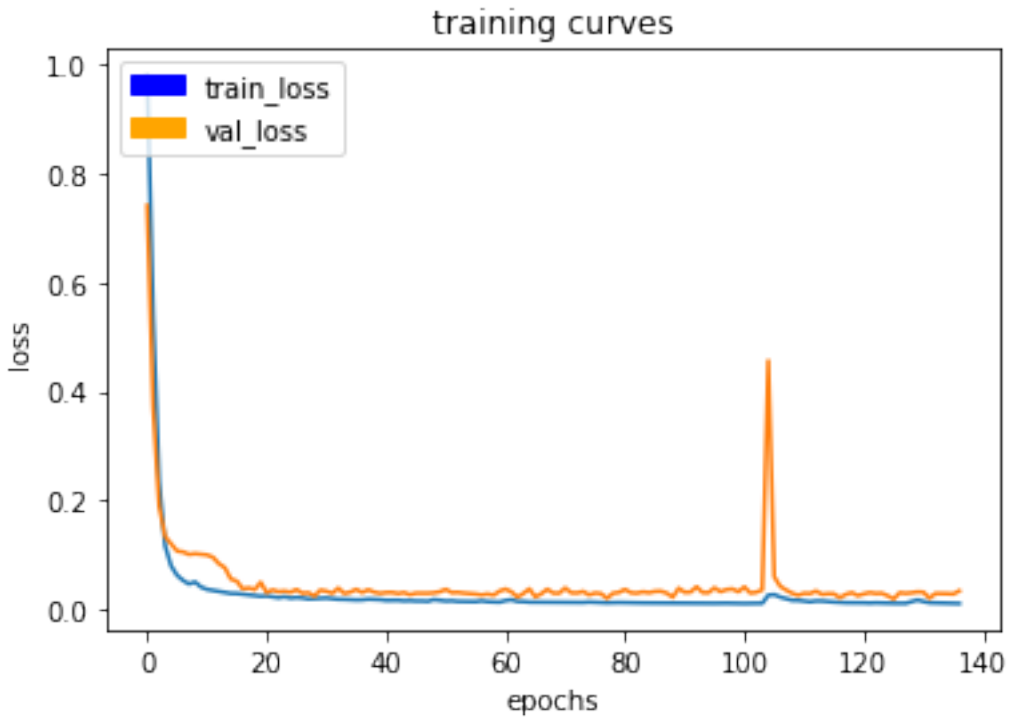

```
41/41 [==============================] - 58s - loss: 0.0117 - val_loss: 0.0292
Epoch 135/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0115
```



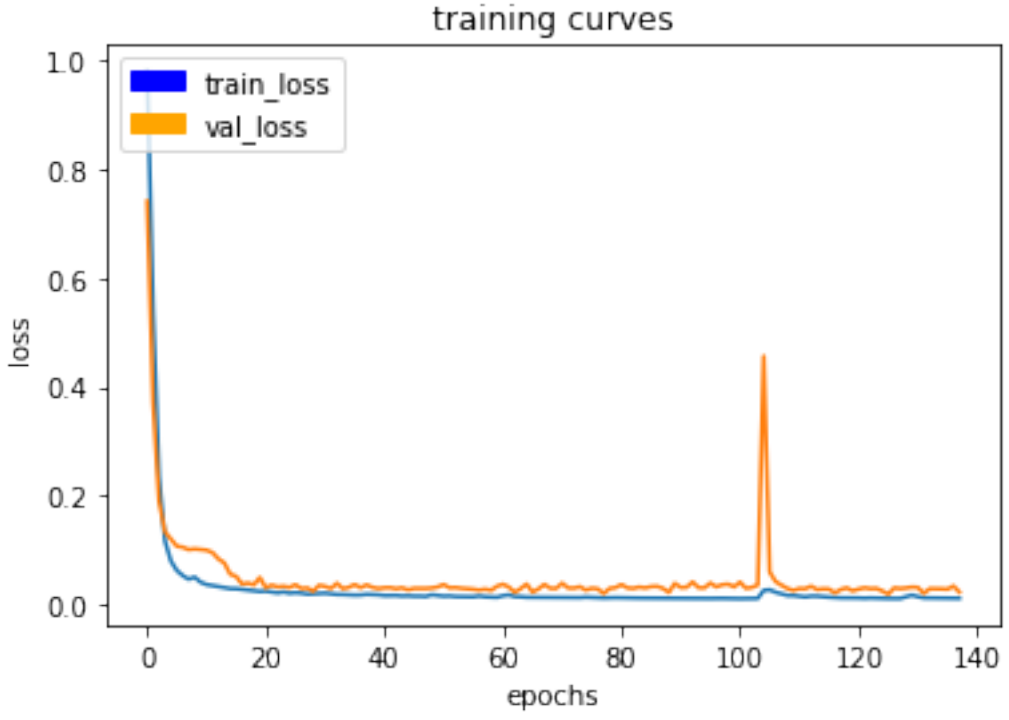
```
41/41 [==============================] - 57s - loss: 0.0115 - val_loss: 0.0290
Epoch 136/200
40/41 [============================>.] - ETA: 1s - loss: 0.0114
```



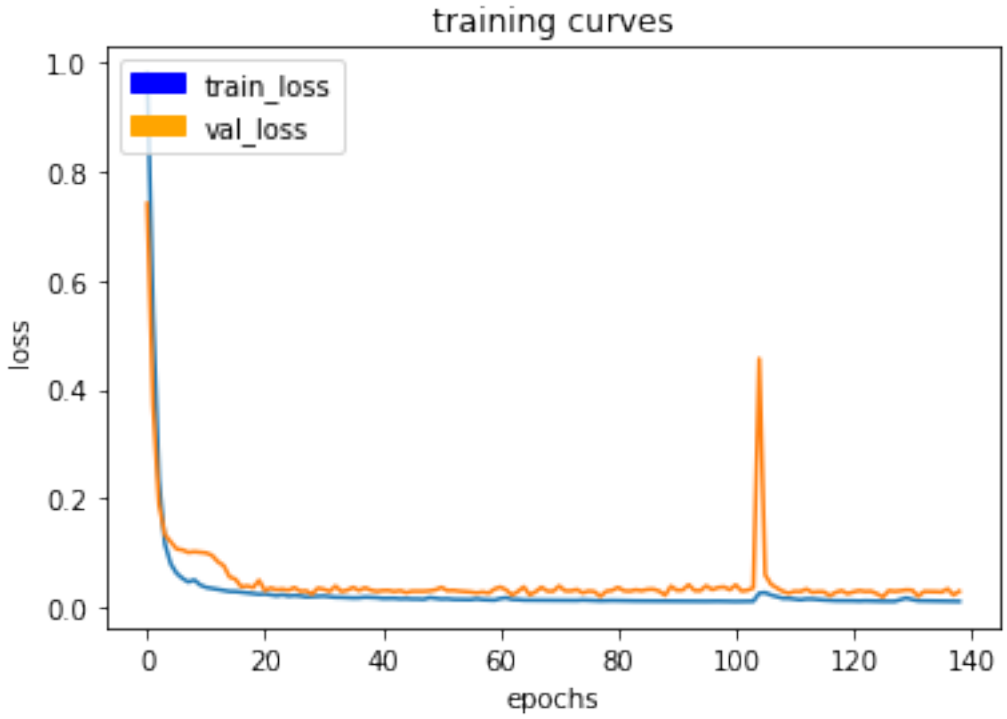

```
41/41 [==============================] - 58s - loss: 0.0114 - val_loss: 0.0284
Epoch 137/200
40/41 [============================>.] - ETA: 1s - loss: 0.0111
```



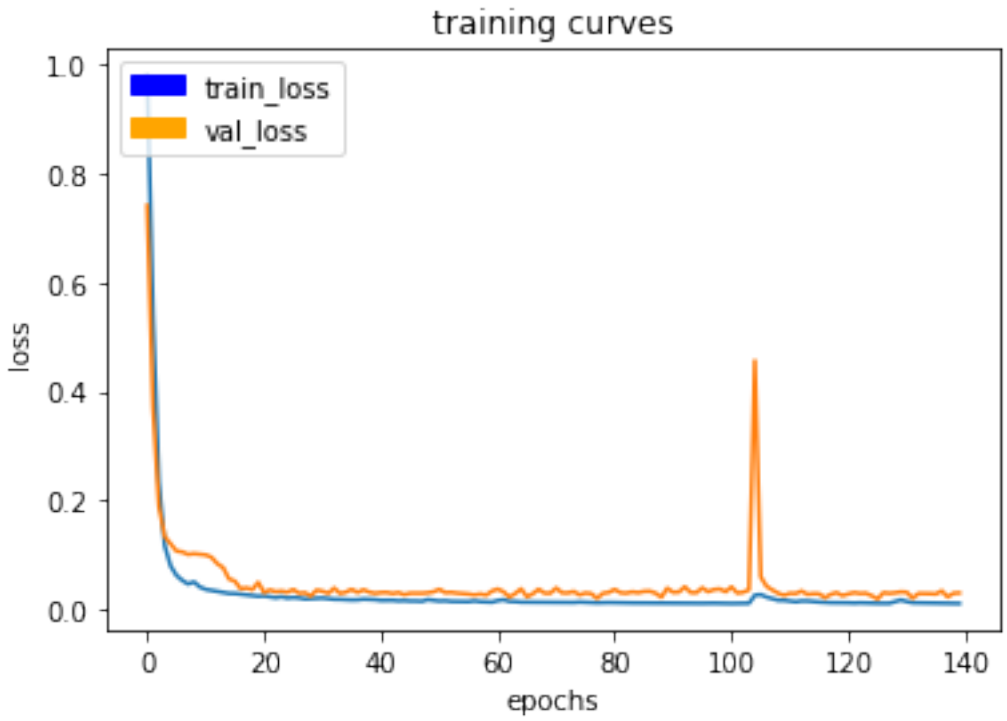

```
41/41 [==============================] - 58s - loss: 0.0110 - val_loss: 0.0342
Epoch 138/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0117
```



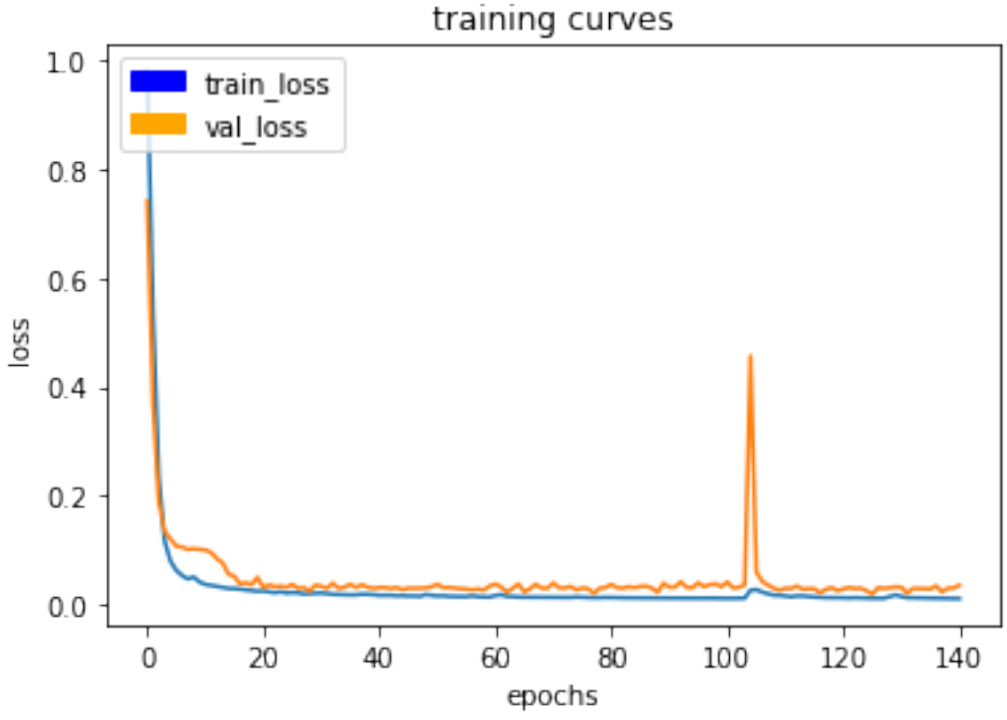
```
41/41 [==============================] - 58s - loss: 0.0117 - val_loss: 0.0230
Epoch 139/200
40/41 [============================>.] - ETA: 1s - loss: 0.0112
```



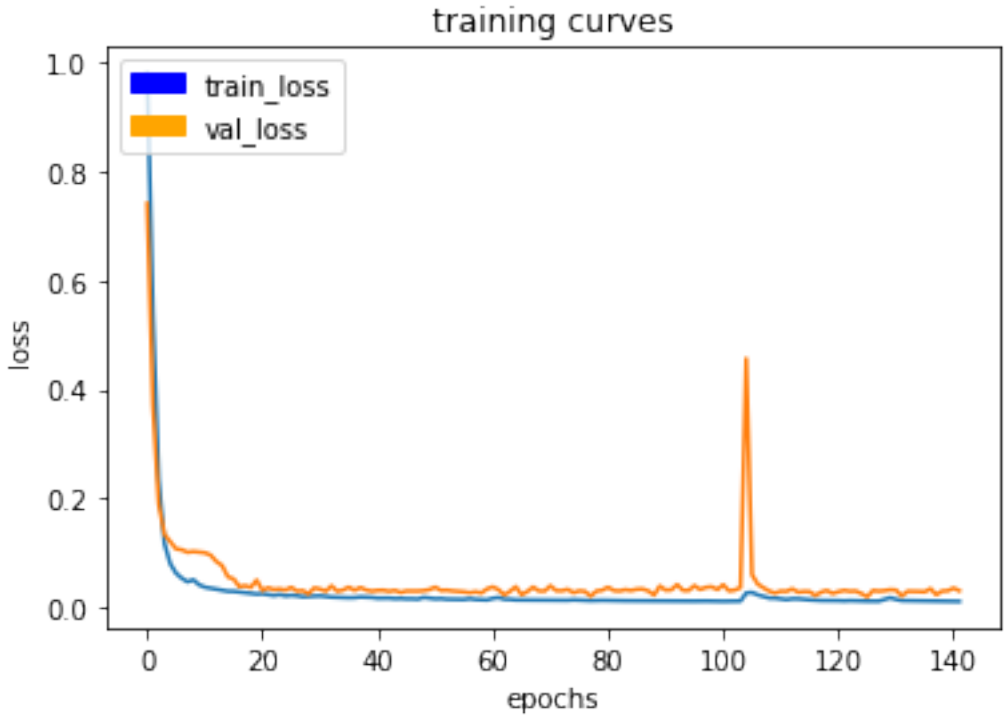

```
41/41 [==============================] - 58s - loss: 0.0112 - val_loss: 0.0298
Epoch 140/200
40/41 [============================>.] - ETA: 1s - loss: 0.0111
```



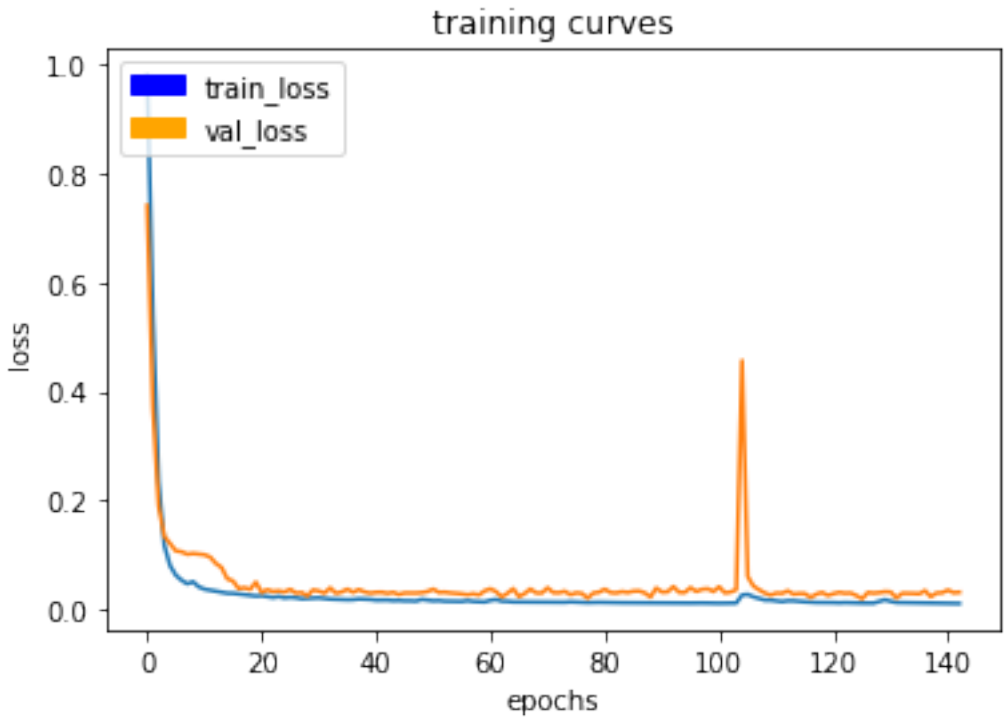

```
41/41 [==============================] - 58s - loss: 0.0111 - val_loss: 0.0303
Epoch 141/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0107
```



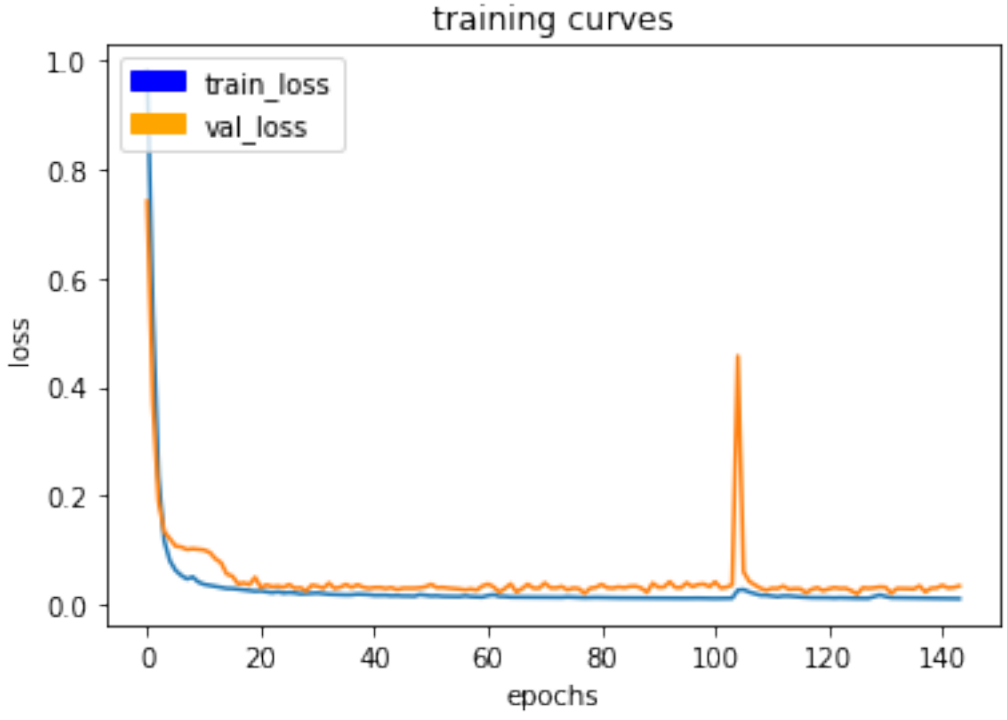
```
41/41 [==============================] - 57s - loss: 0.0107 - val_loss: 0.0352
Epoch 142/200
40/41 [============================>.] - ETA: 1s - loss: 0.0108
```



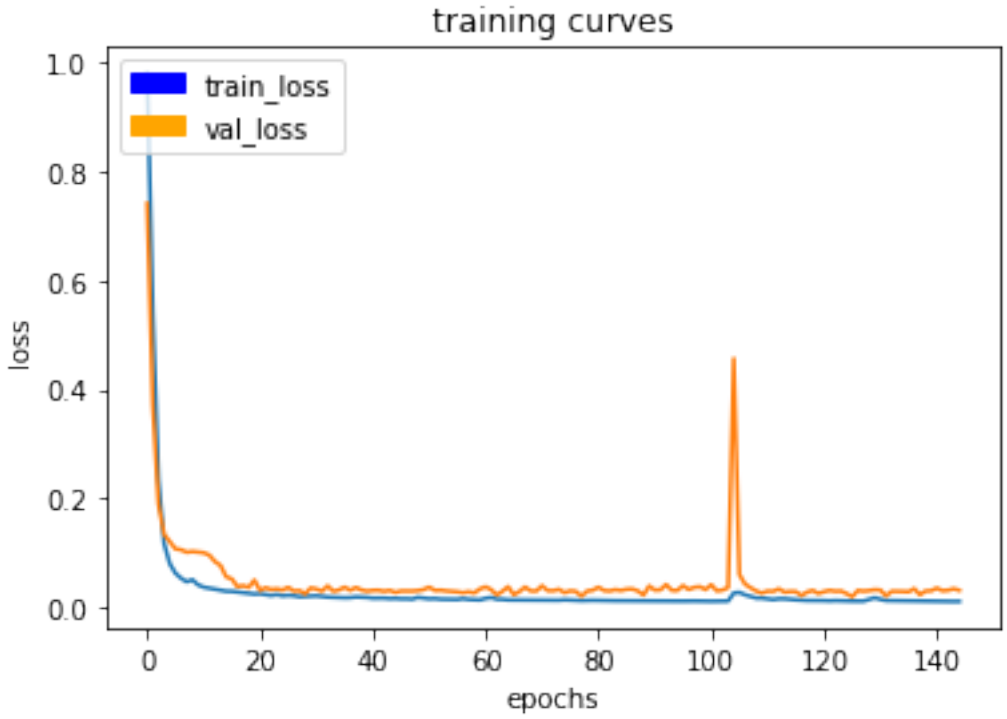

```
41/41 [==============================] - 57s - loss: 0.0108 - val_loss: 0.0303
Epoch 143/200
40/41 [============================>.] - ETA: 1s - loss: 0.0107
```



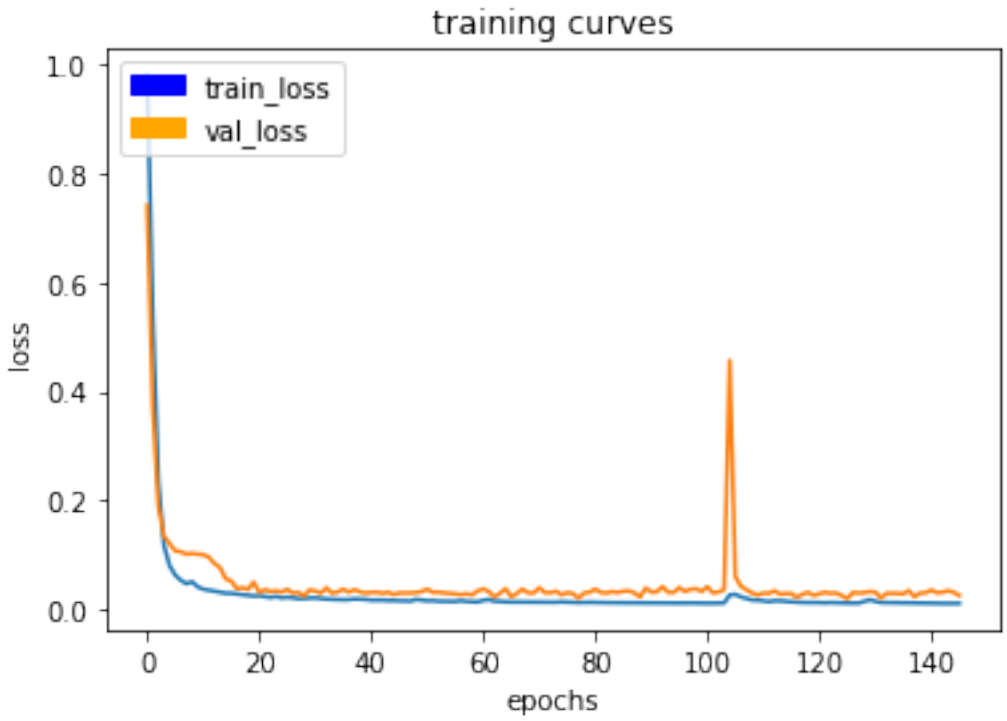

```
41/41 [==============================] - 57s - loss: 0.0107 - val_loss: 0.0313
Epoch 144/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0107
```



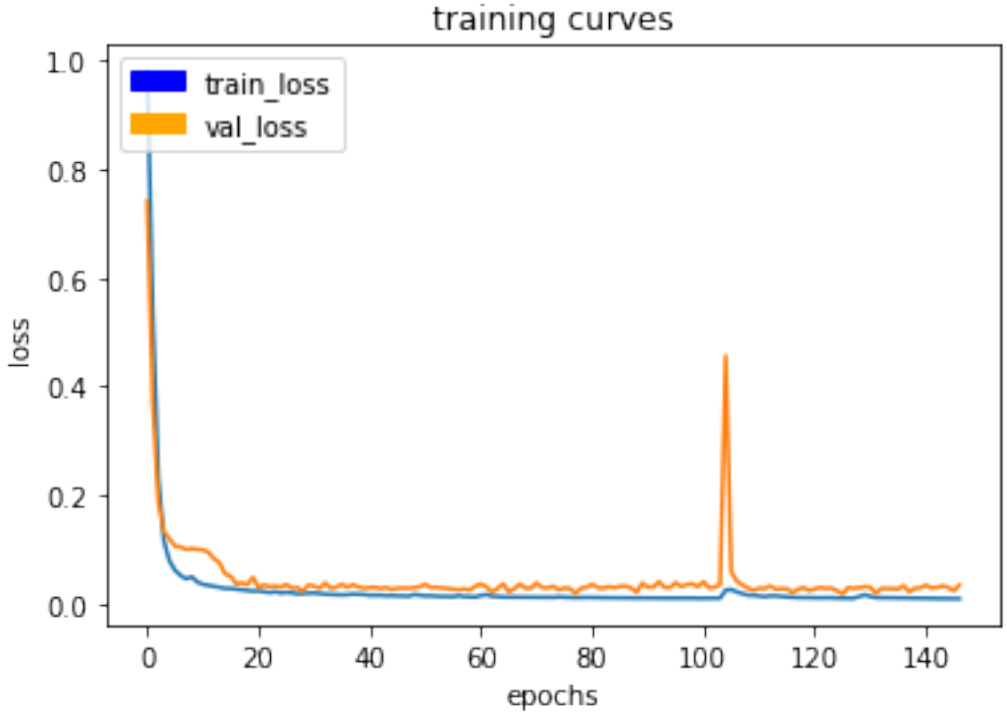
```
41/41 [==============================] - 58s - loss: 0.0107 - val_loss: 0.0340
Epoch 145/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0108
```



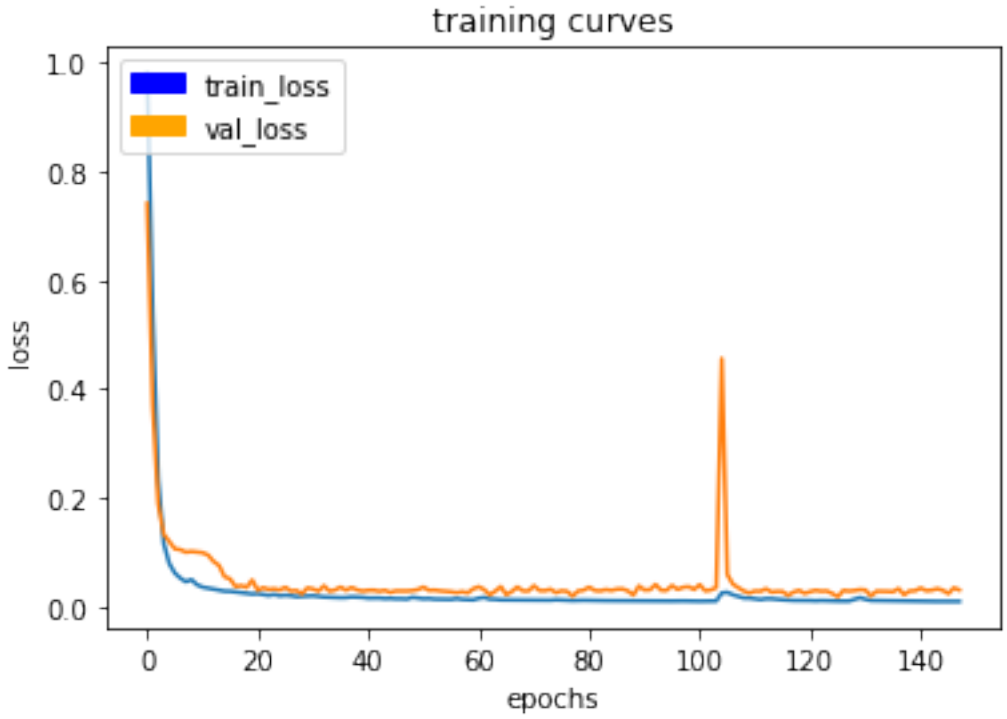

```
41/41 [==============================] - 58s - loss: 0.0108 - val_loss: 0.0311
Epoch 146/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0109
```



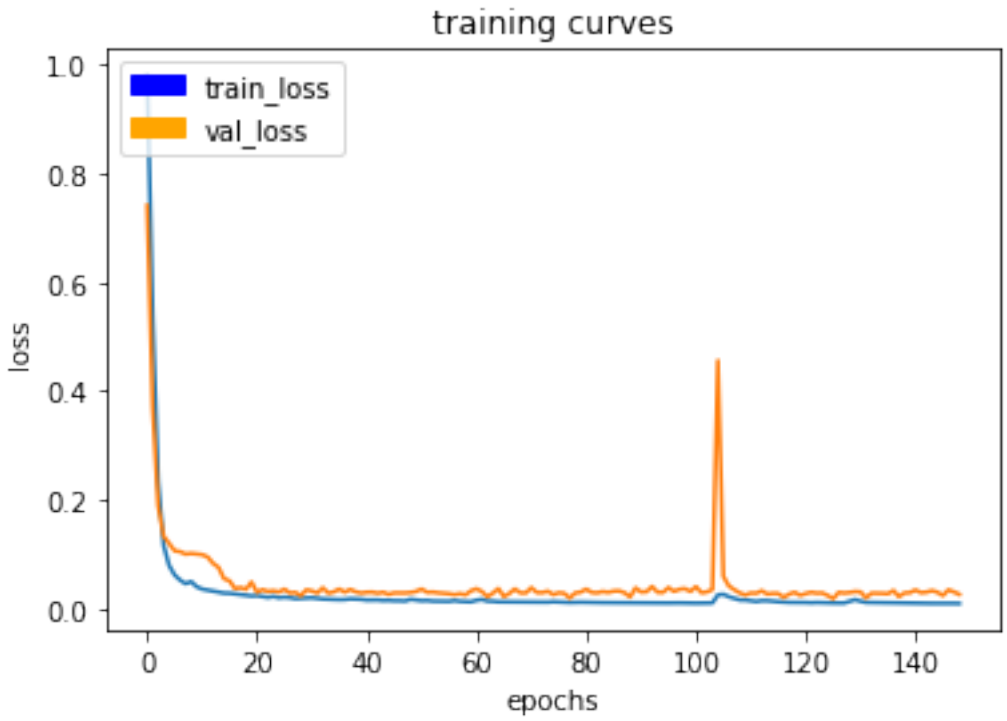

```
41/41 [==============================] - 58s - loss: 0.0109 - val_loss: 0.0250
Epoch 147/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0105
```



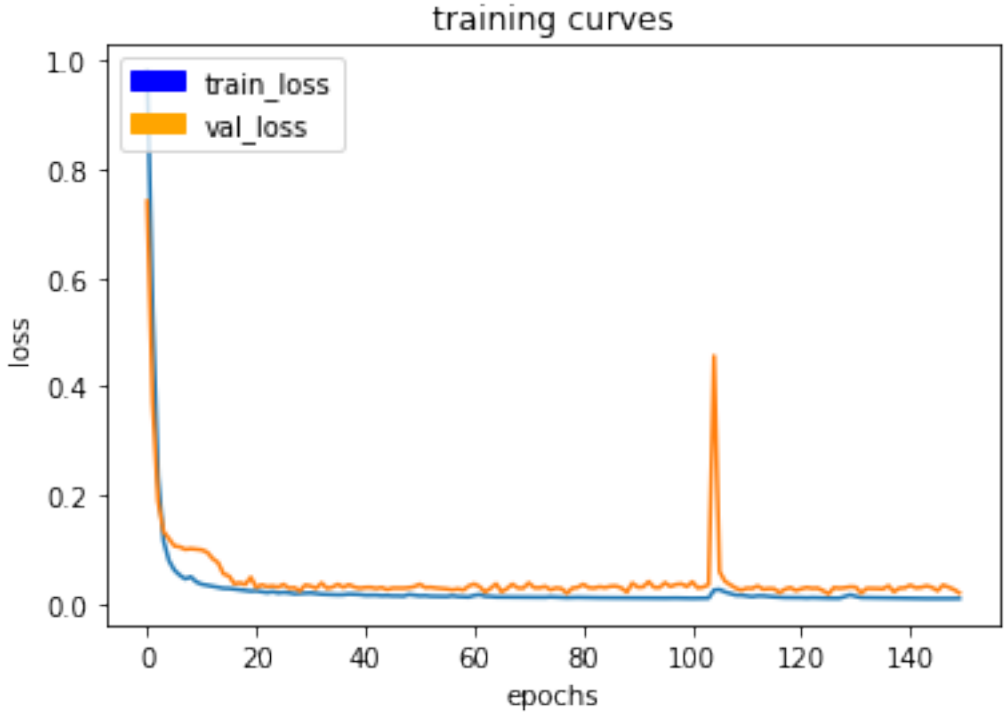
```
41/41 [==============================] - 57s - loss: 0.0105 - val_loss: 0.0354
Epoch 148/200
40/41 [============================>.] - ETA: 1s - loss: 0.0107
```



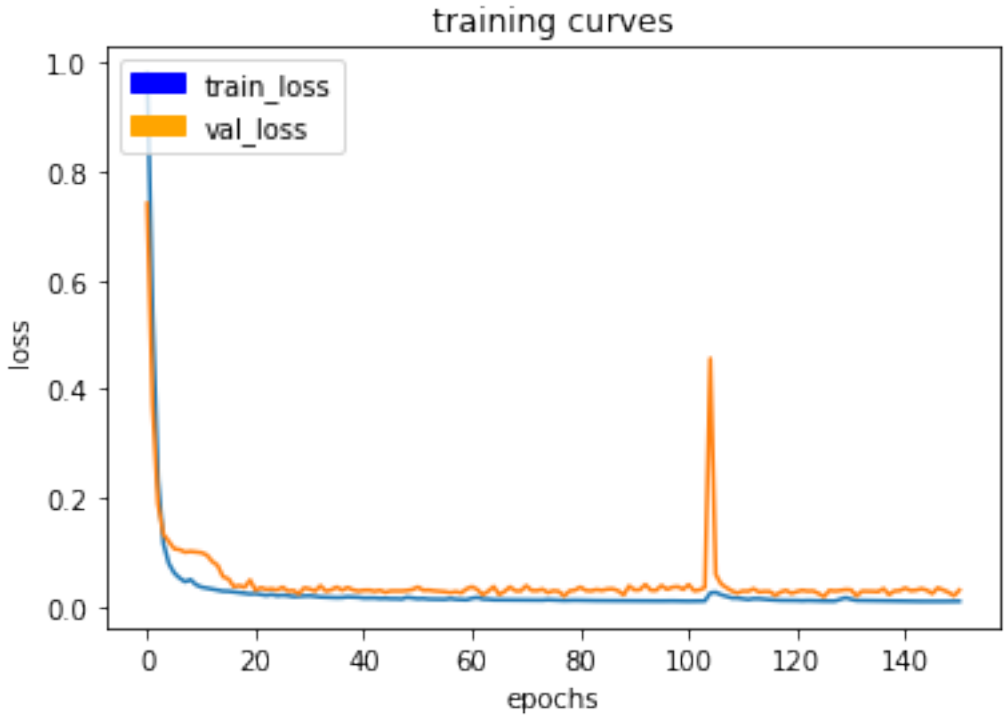

```
41/41 [==============================] - 57s - loss: 0.0107 - val_loss: 0.0317
Epoch 149/200
40/41 [============================>.] - ETA: 1s - loss: 0.0105
```



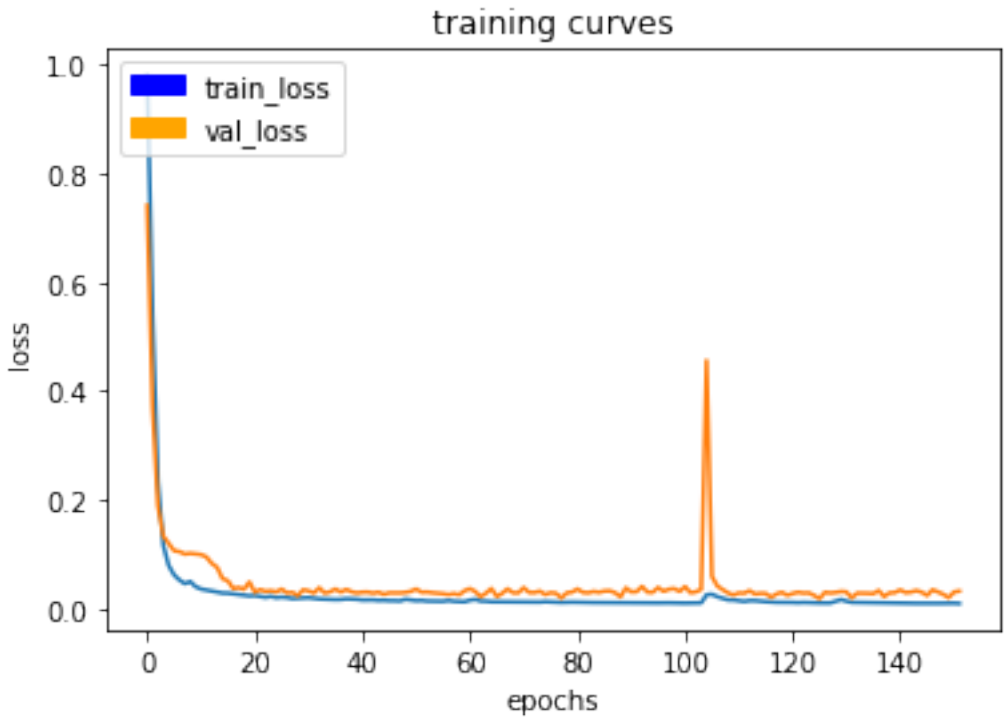

```
41/41 [==============================] - 58s - loss: 0.0105 - val_loss: 0.0272
Epoch 150/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0108
```



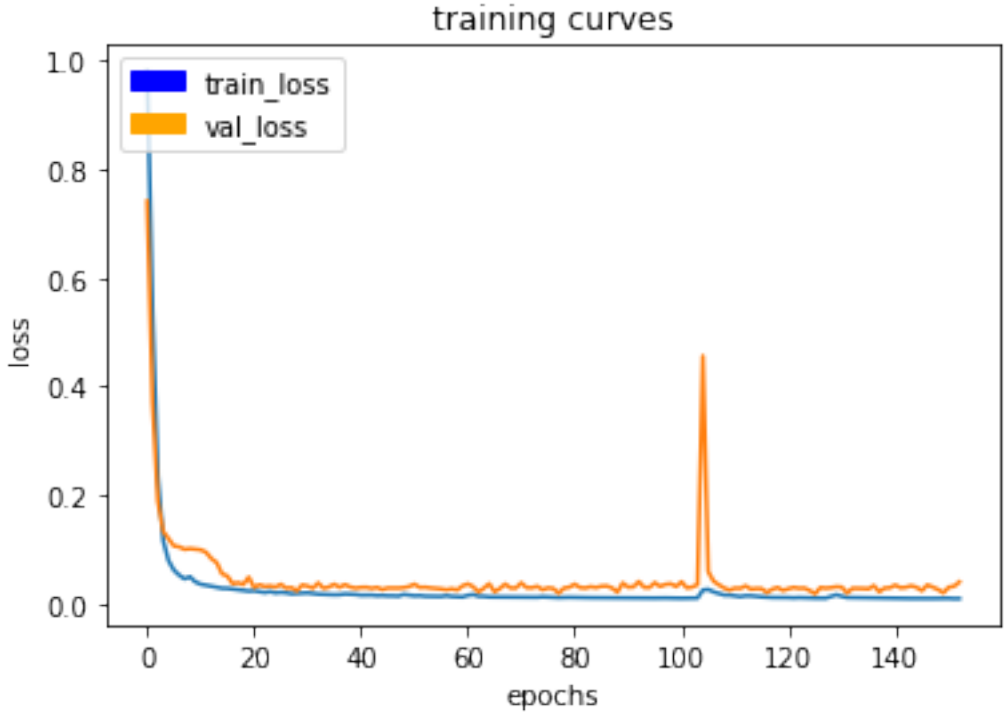
```
41/41 [==============================] - 57s - loss: 0.0108 - val_loss: 0.0209
Epoch 151/200
40/41 [============================>.] - ETA: 1s - loss: 0.0109
```



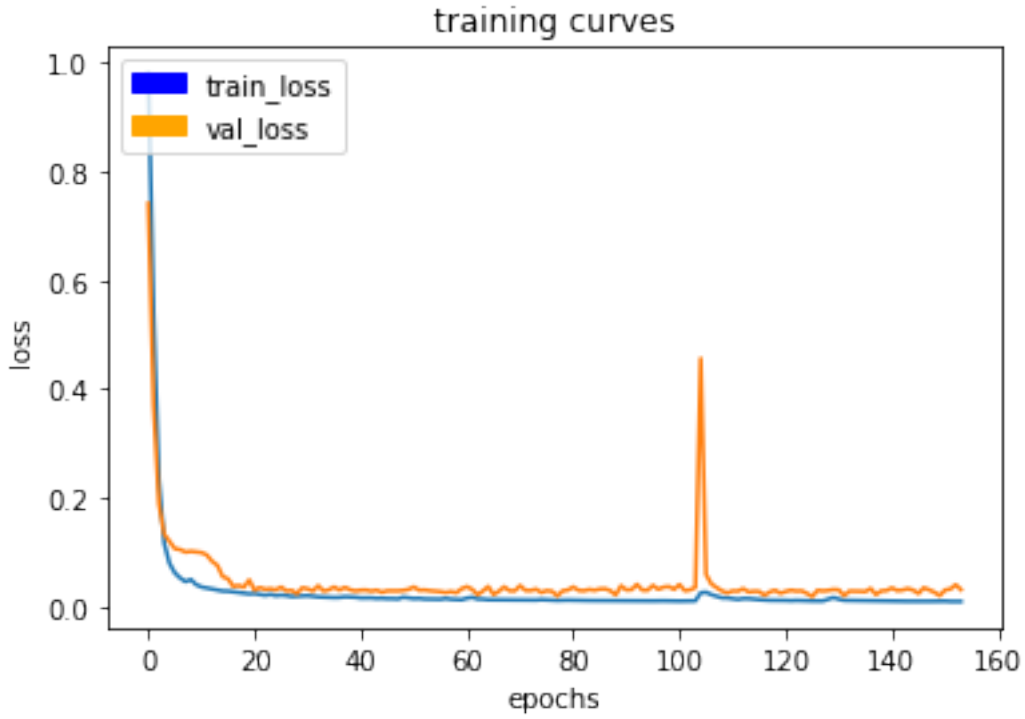

```
41/41 [==============================] - 57s - loss: 0.0109 - val_loss: 0.0314
Epoch 152/200
40/41 [============================>.] - ETA: 1s - loss: 0.0103
```



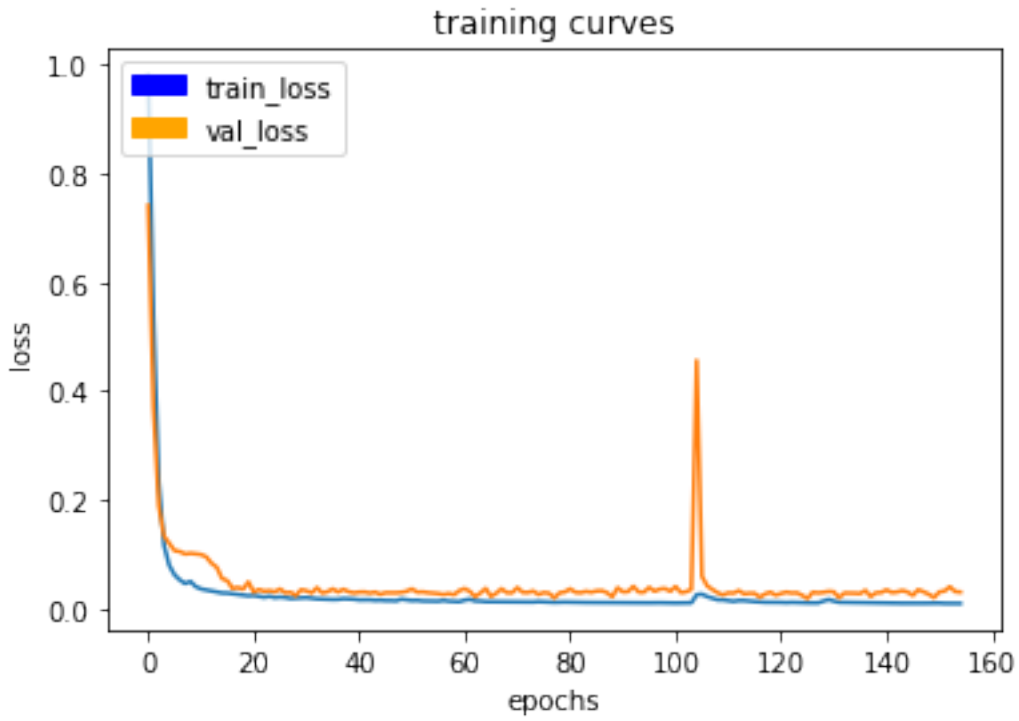

```
41/41 [==============================] - 57s - loss: 0.0103 - val_loss: 0.0330
Epoch 153/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0105
```



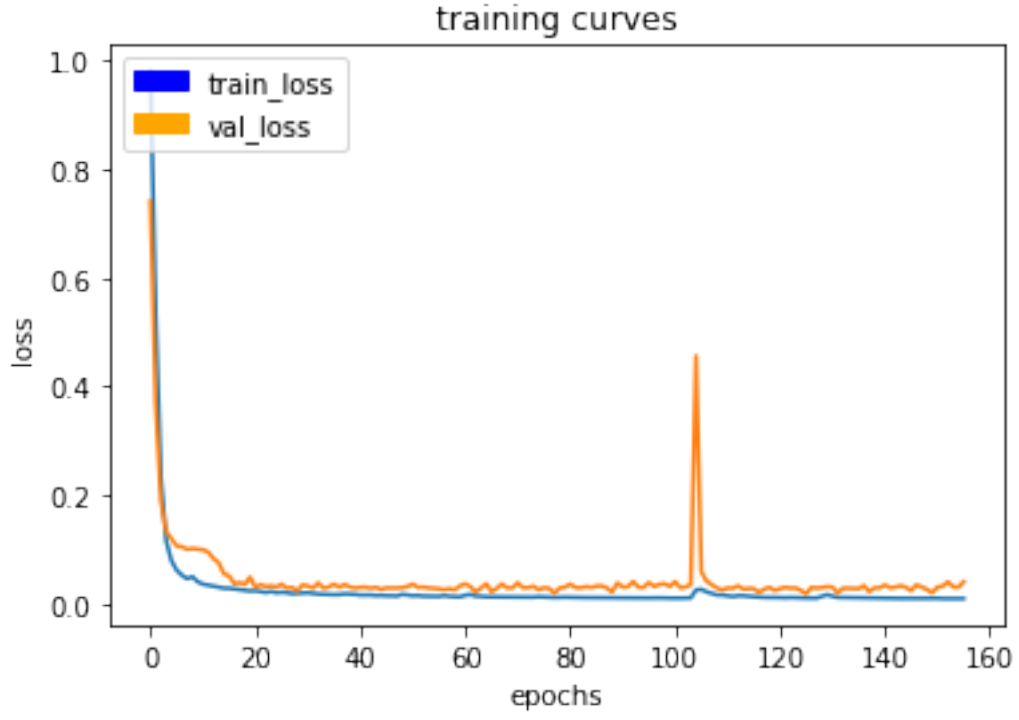
```
41/41 [==============================] - 57s - loss: 0.0105 - val_loss: 0.0410
Epoch 154/200
40/41 [============================>.] - ETA: 1s - loss: 0.0103
```



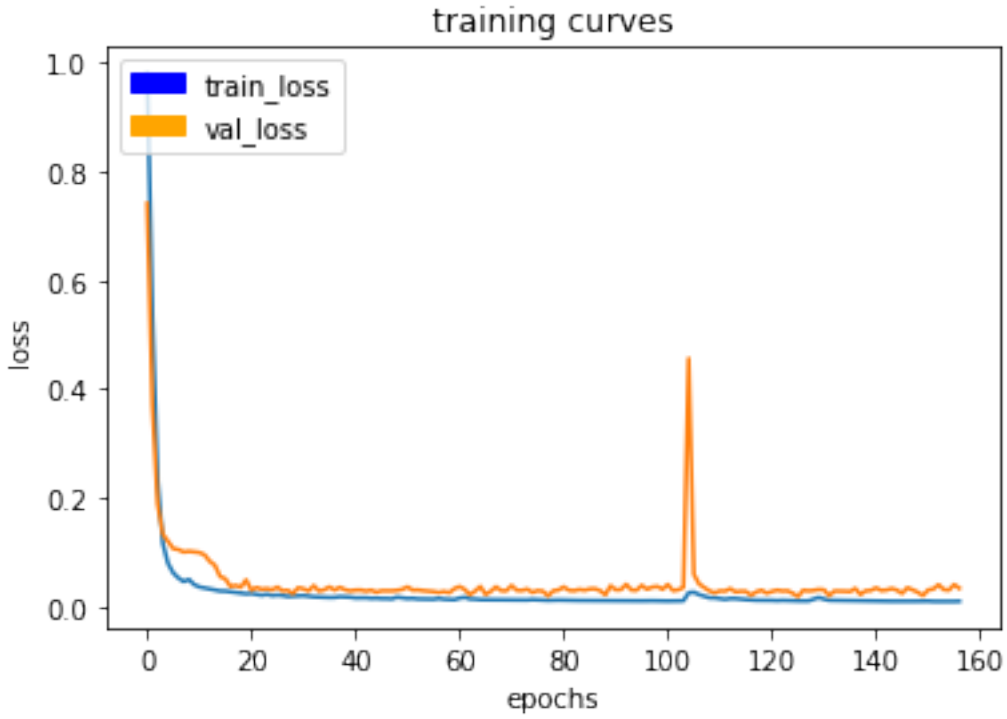

```
41/41 [==============================] - 58s - loss: 0.0103 - val_loss: 0.0320
Epoch 155/200
40/41 [============================>.] - ETA: 1s - loss: 0.0102
```



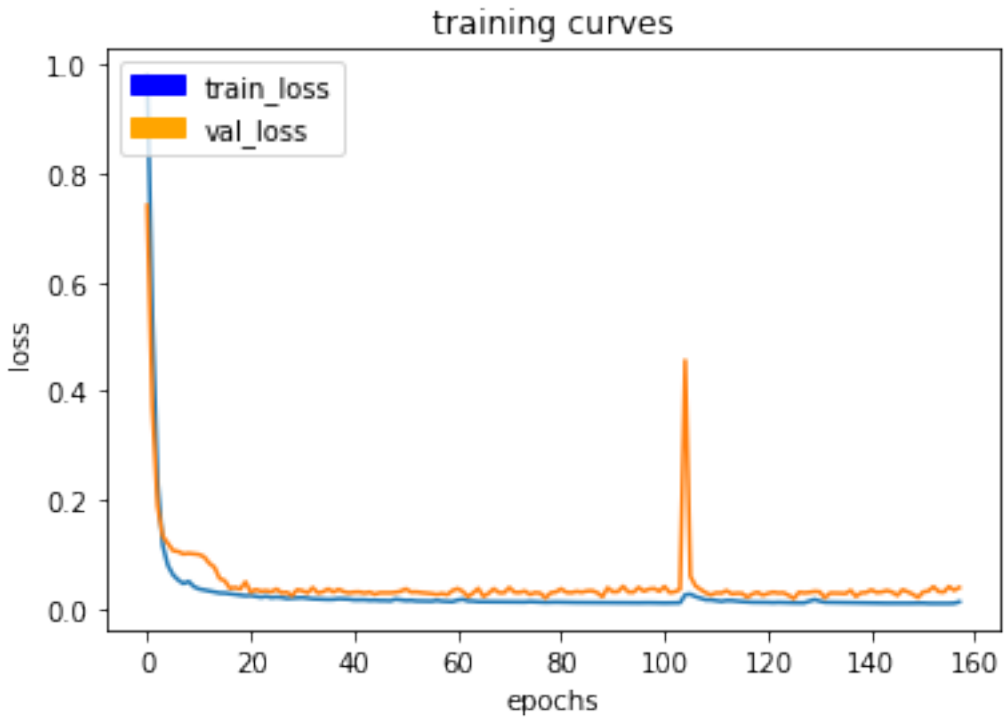

```
41/41 [==============================] - 57s - loss: 0.0102 - val_loss: 0.0311
Epoch 156/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0103
```



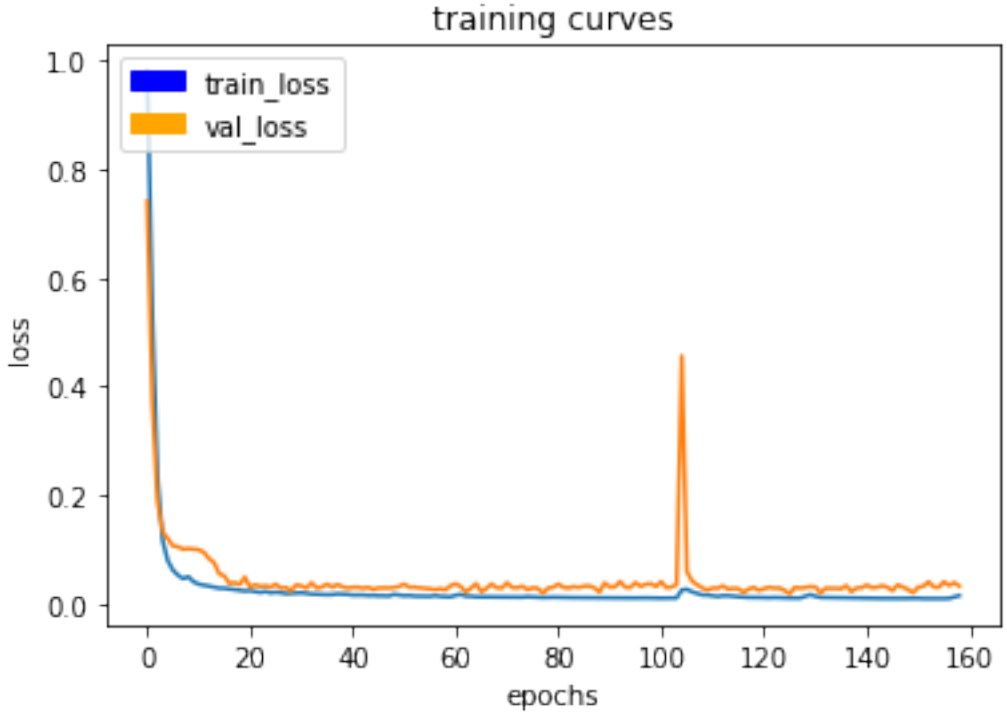
```
41/41 [==============================] - 57s - loss: 0.0103 - val_loss: 0.0412
Epoch 157/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0107
```



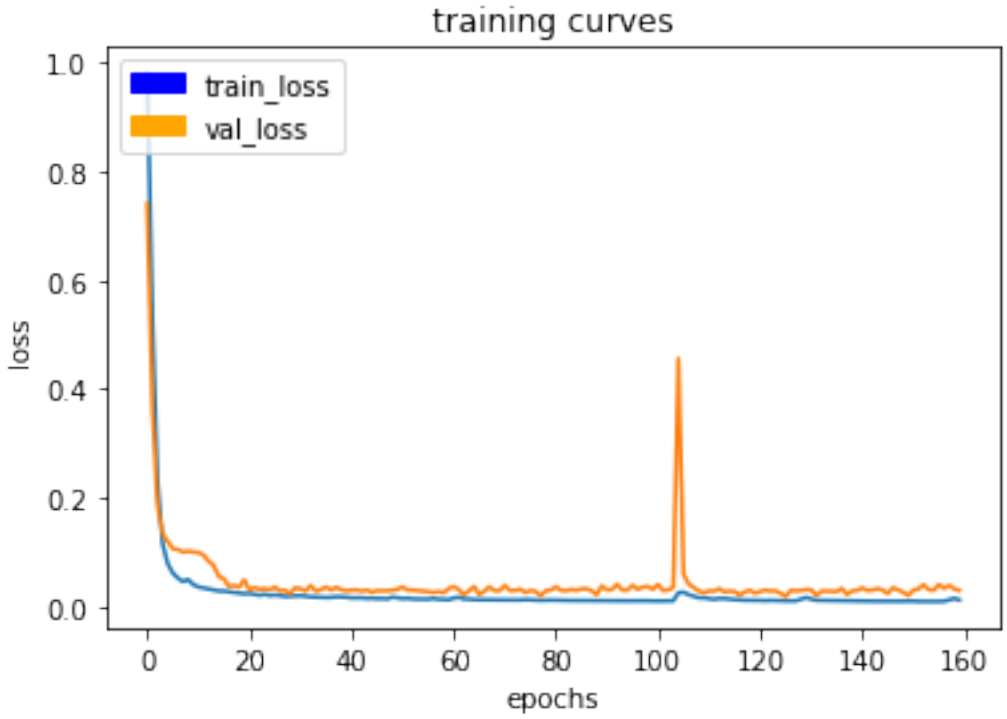

```
41/41 [==============================] - 58s - loss: 0.0106 - val_loss: 0.0344
Epoch 158/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0133
```



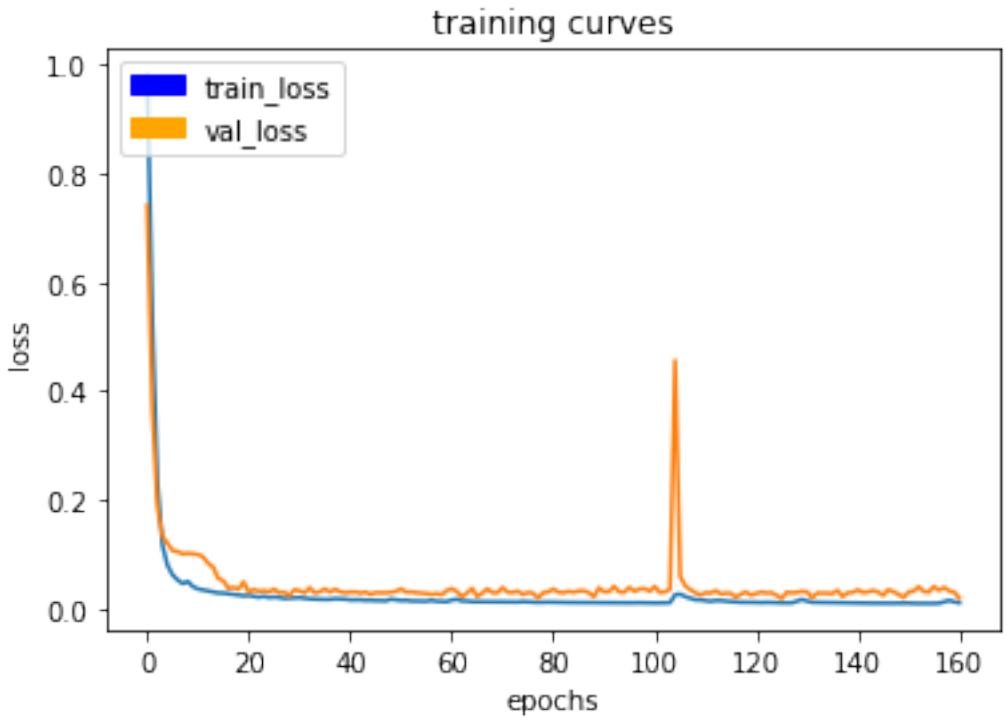

```
41/41 [==============================] - 58s - loss: 0.0133 - val_loss: 0.0395
Epoch 159/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0159
```



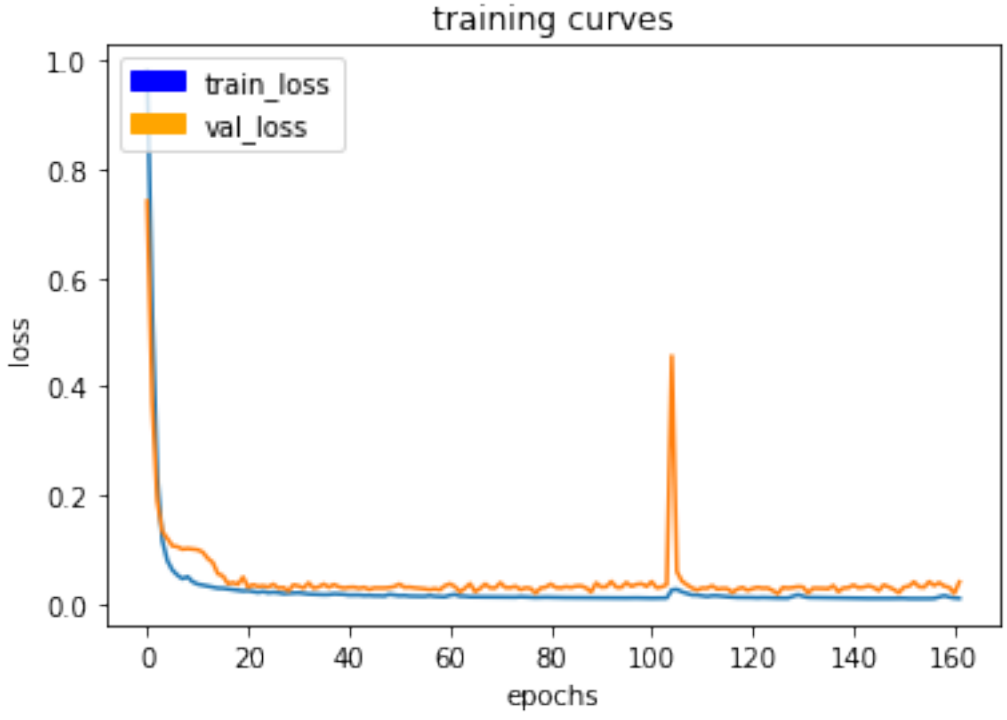
```
41/41 [==============================] - 58s - loss: 0.0159 - val_loss: 0.0333
Epoch 160/200
40/41 [============================>.] - ETA: 1s - loss: 0.0131
```



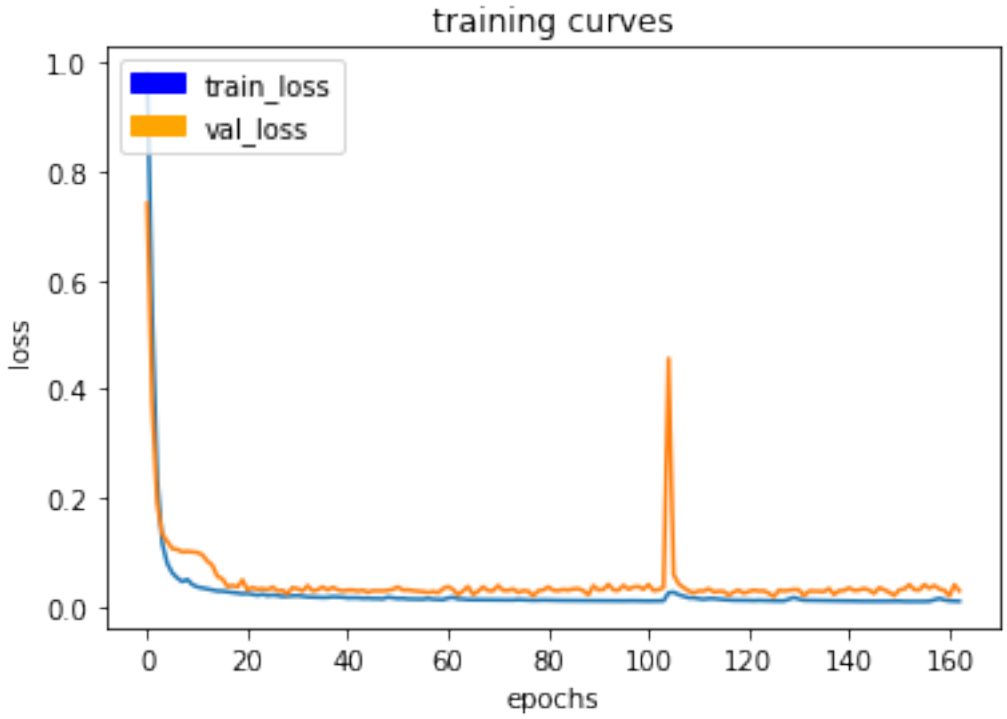

```
41/41 [==============================] - 58s - loss: 0.0131 - val_loss: 0.0309
Epoch 161/200
40/41 [============================>.] - ETA: 1s - loss: 0.0114
```



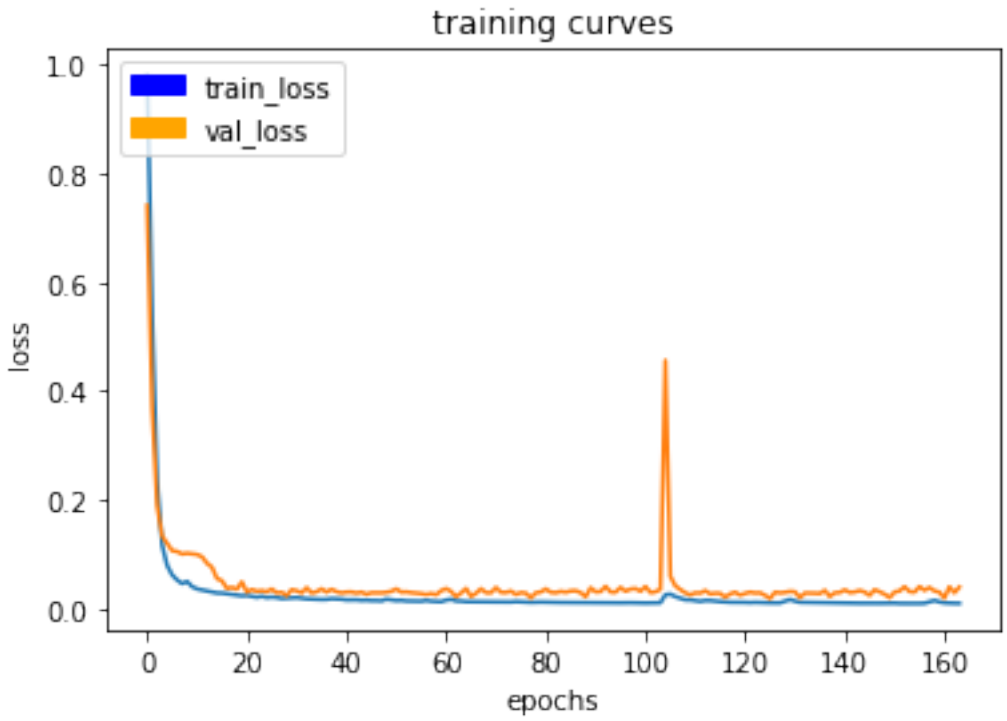

```
41/41 [==============================] - 57s - loss: 0.0114 - val_loss: 0.0200
Epoch 162/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0108
```



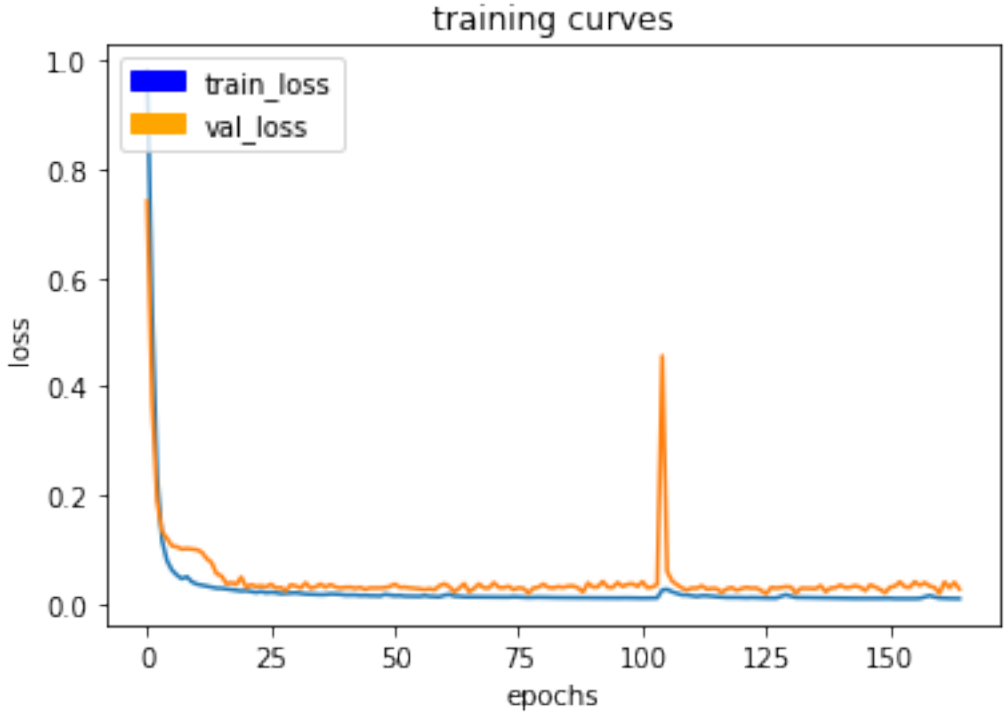
```
41/41 [==============================] - 57s - loss: 0.0108 - val_loss: 0.0409
Epoch 163/200
40/41 [============================>.] - ETA: 1s - loss: 0.0106
```



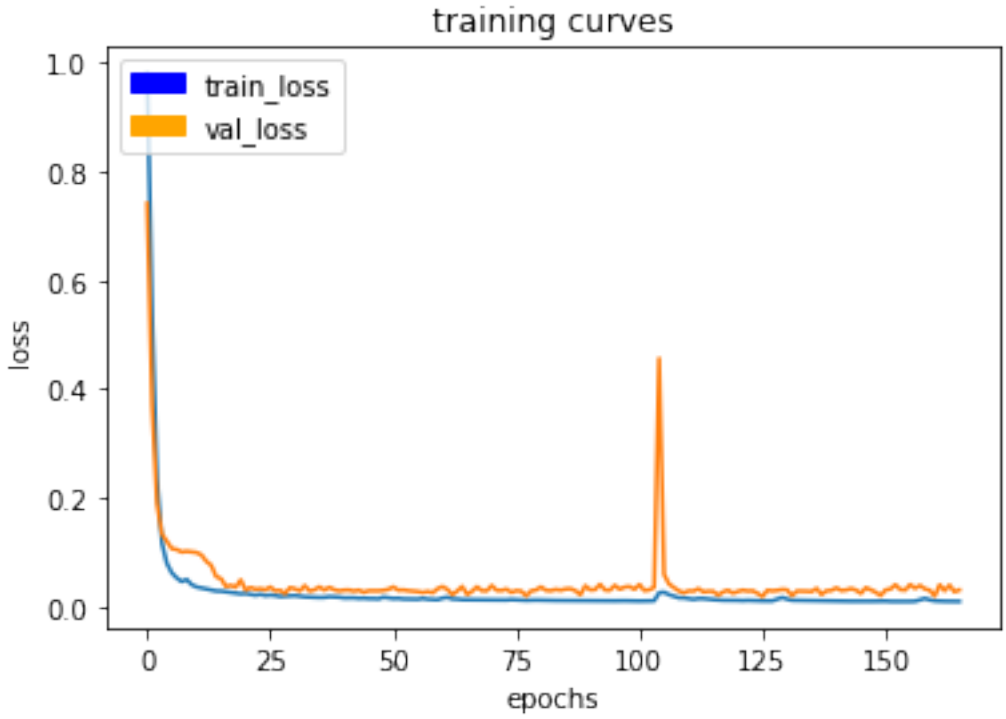

```
41/41 [==============================] - 58s - loss: 0.0106 - val_loss: 0.0300
Epoch 164/200
40/41 [============================>.] - ETA: 1s - loss: 0.0105
```



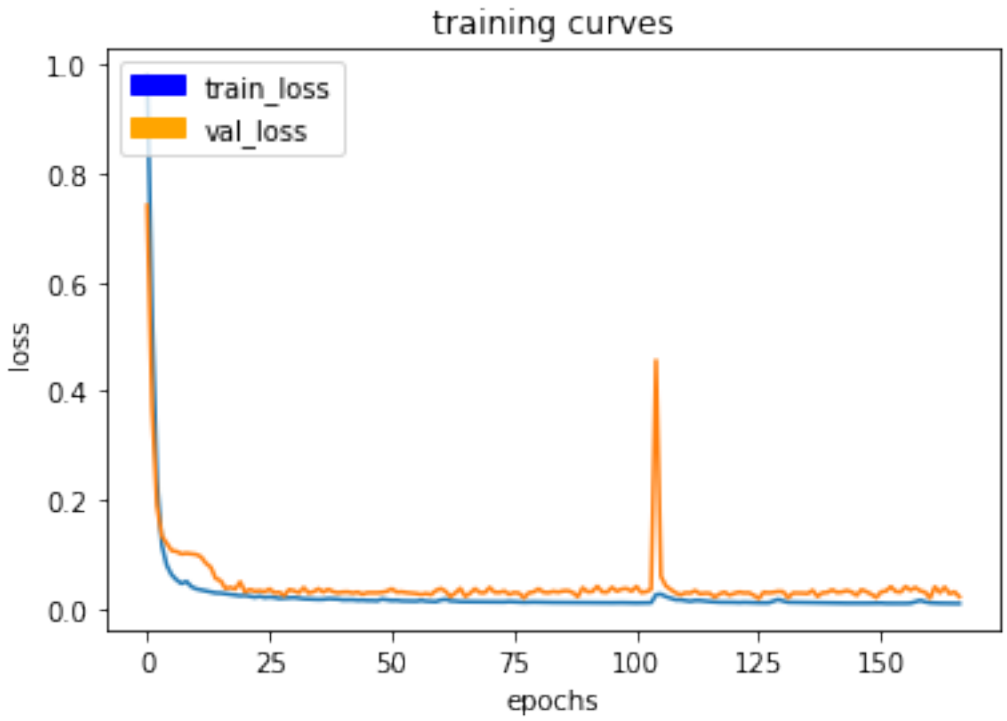

```
41/41 [==============================] - 58s - loss: 0.0105 - val_loss: 0.0402
Epoch 165/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0103
```



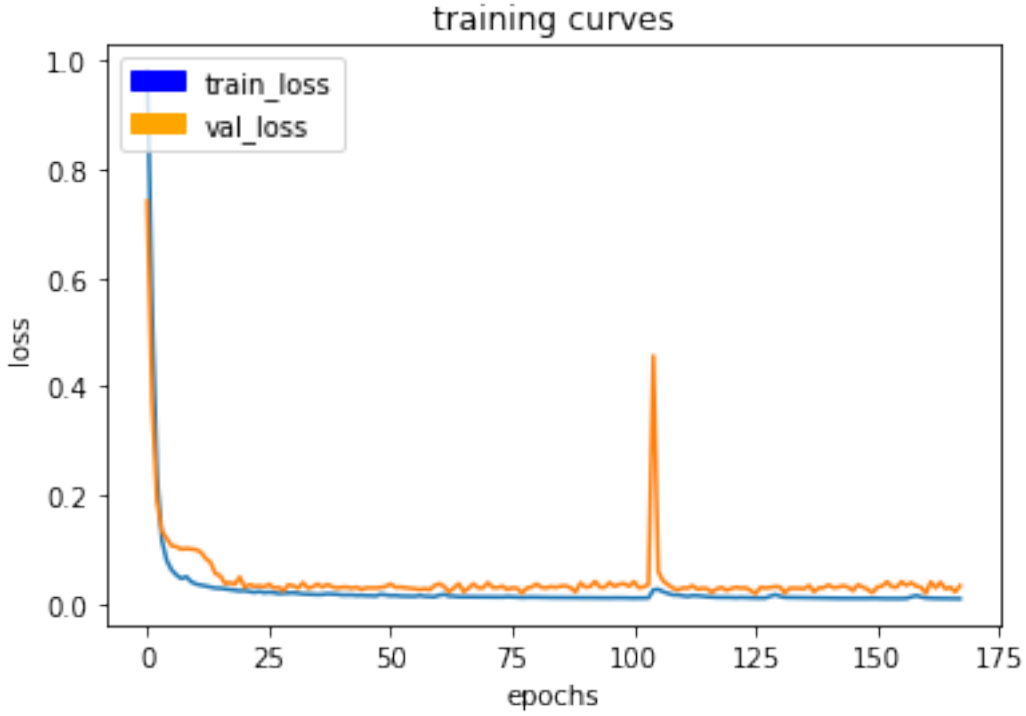
```
41/41 [==============================] - 58s - loss: 0.0103 - val_loss: 0.0280
Epoch 166/200
40/41 [============================>.] - ETA: 1s - loss: 0.0103
```



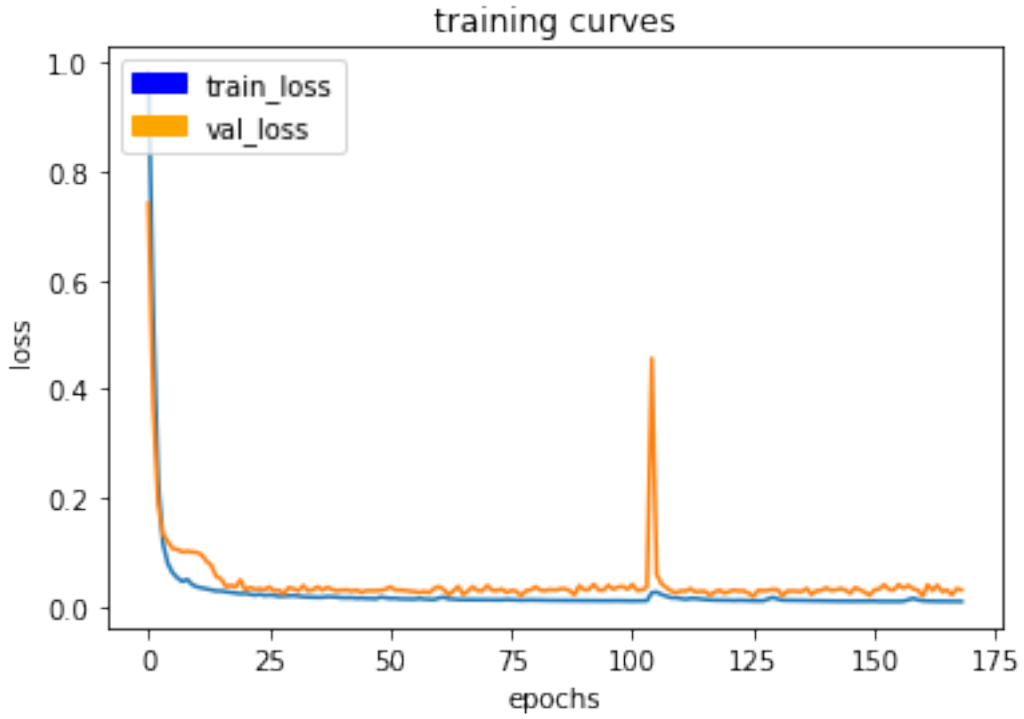

```
41/41 [==============================] - 58s - loss: 0.0104 - val_loss: 0.0313
Epoch 167/200
40/41 [============================>.] - ETA: 1s - loss: 0.0101
```



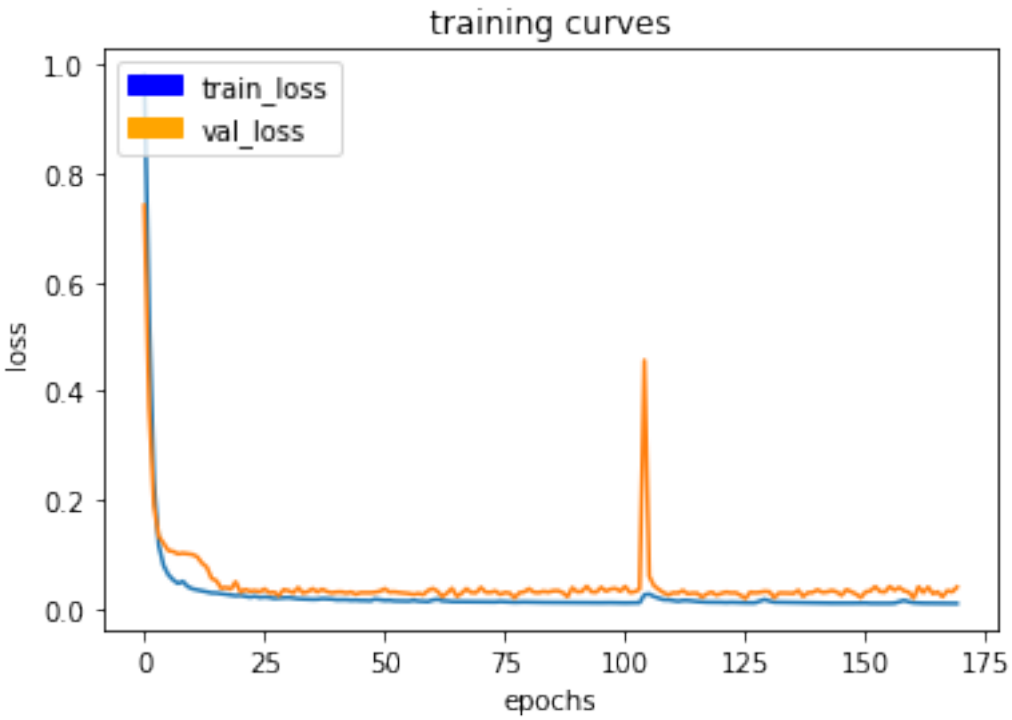

```
41/41 [==============================] - 58s - loss: 0.0101 - val_loss: 0.0224
Epoch 168/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0101
```



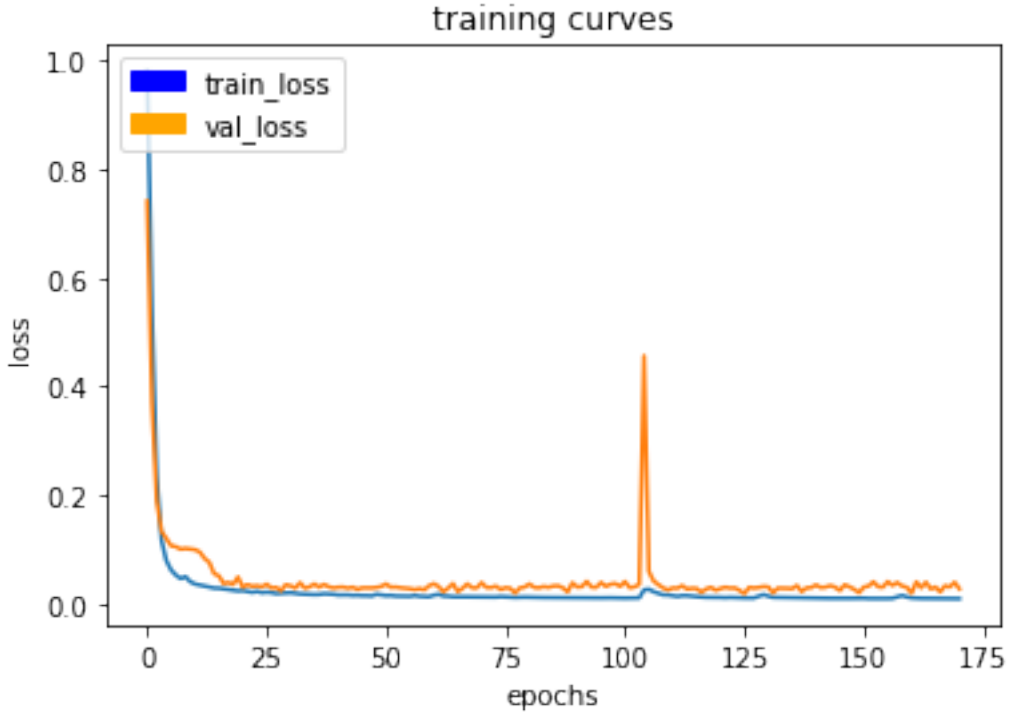
```
41/41 [==============================] - 58s - loss: 0.0101 - val_loss: 0.0336
Epoch 169/200
40/41 [============================>.] - ETA: 1s - loss: 0.0100
```



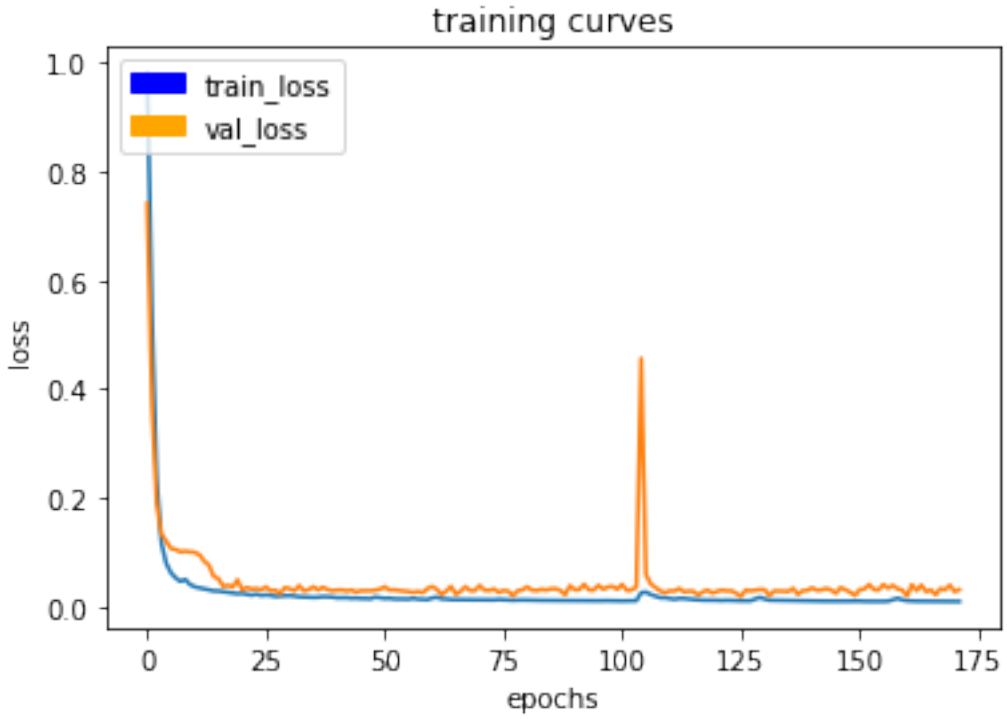

```
41/41 [==============================] - 59s - loss: 0.0101 - val_loss: 0.0313
Epoch 170/200
40/41 [============================>.] - ETA: 1s - loss: 0.0100
```



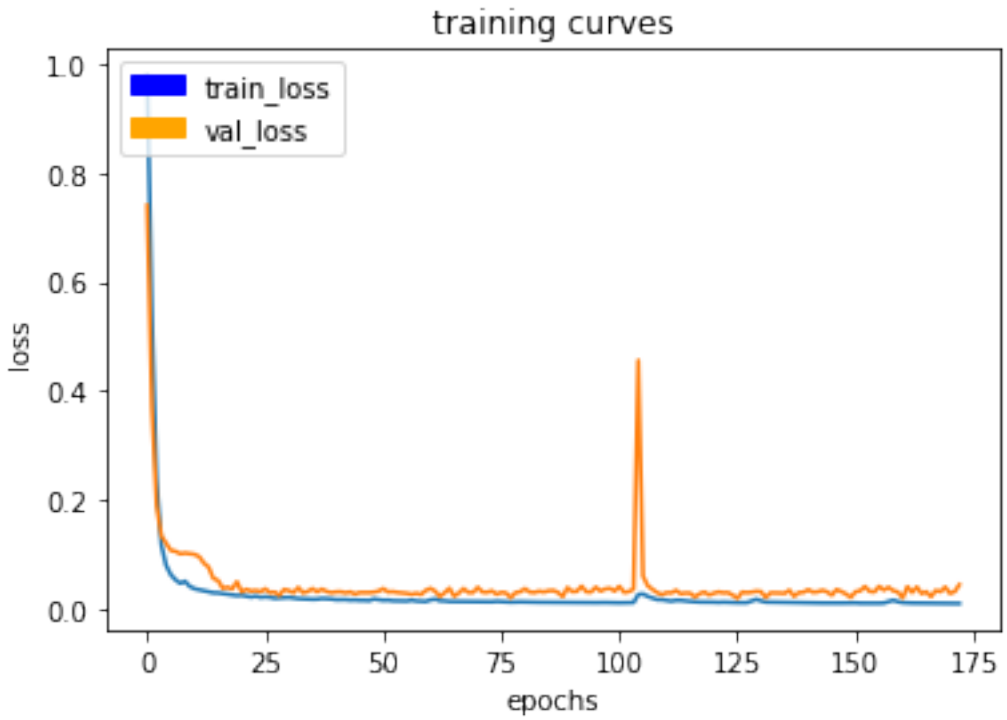

```
41/41 [==============================] - 59s - loss: 0.0101 - val_loss: 0.0400
Epoch 171/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0100
```



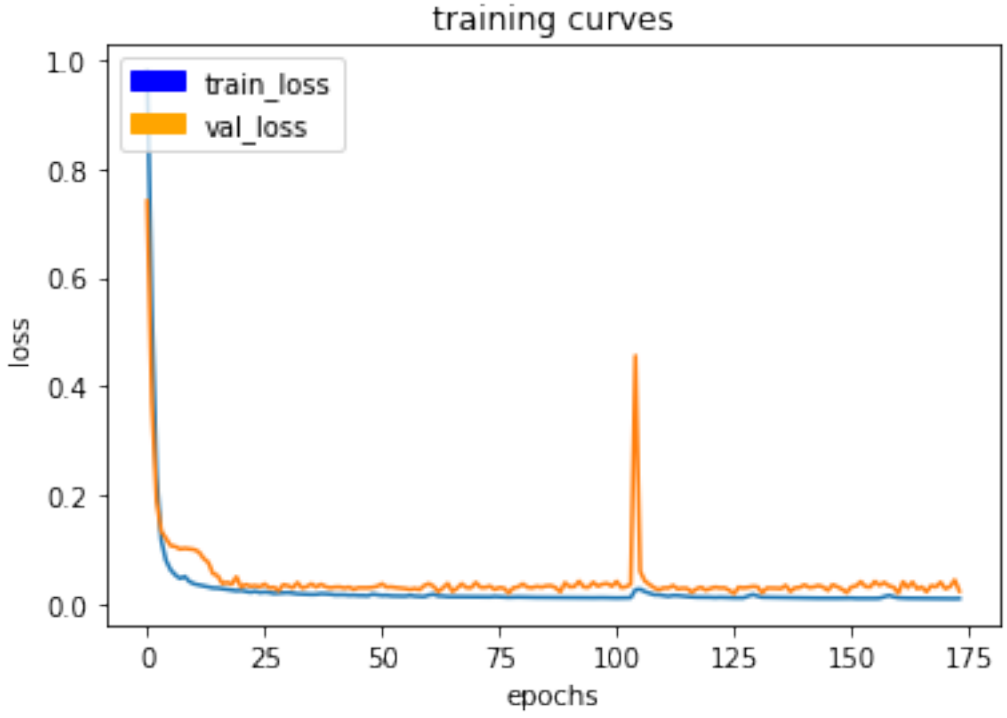
```
41/41 [==============================] - 58s - loss: 0.0100 - val_loss: 0.0282
Epoch 172/200
40/41 [============================>.] - ETA: 1s - loss: 0.0100
```



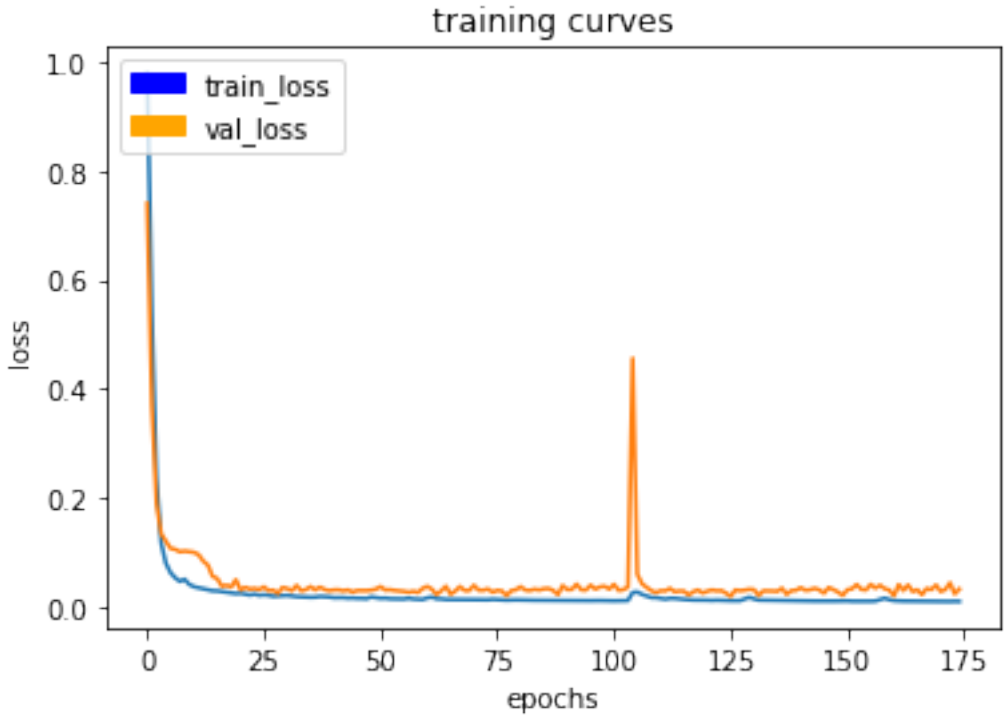

```
41/41 [==============================] - 57s - loss: 0.0100 - val_loss: 0.0316
Epoch 173/200
40/41 [============================>.] - ETA: 1s - loss: 0.0098
```



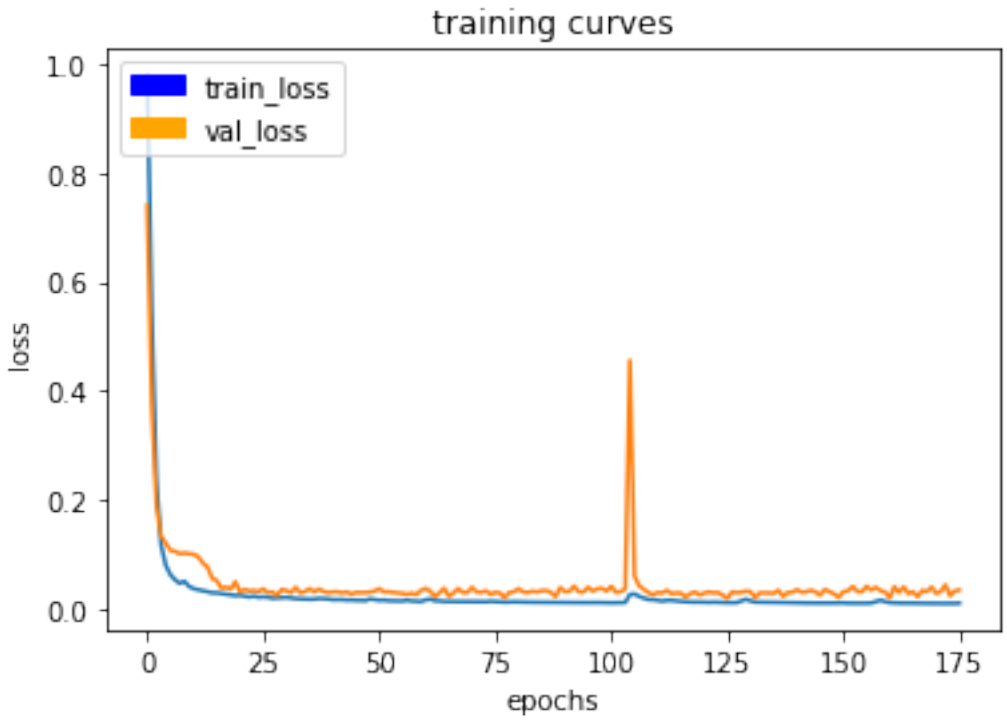

```
41/41 [==============================] - 58s - loss: 0.0098 - val_loss: 0.0441
Epoch 174/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0101
```



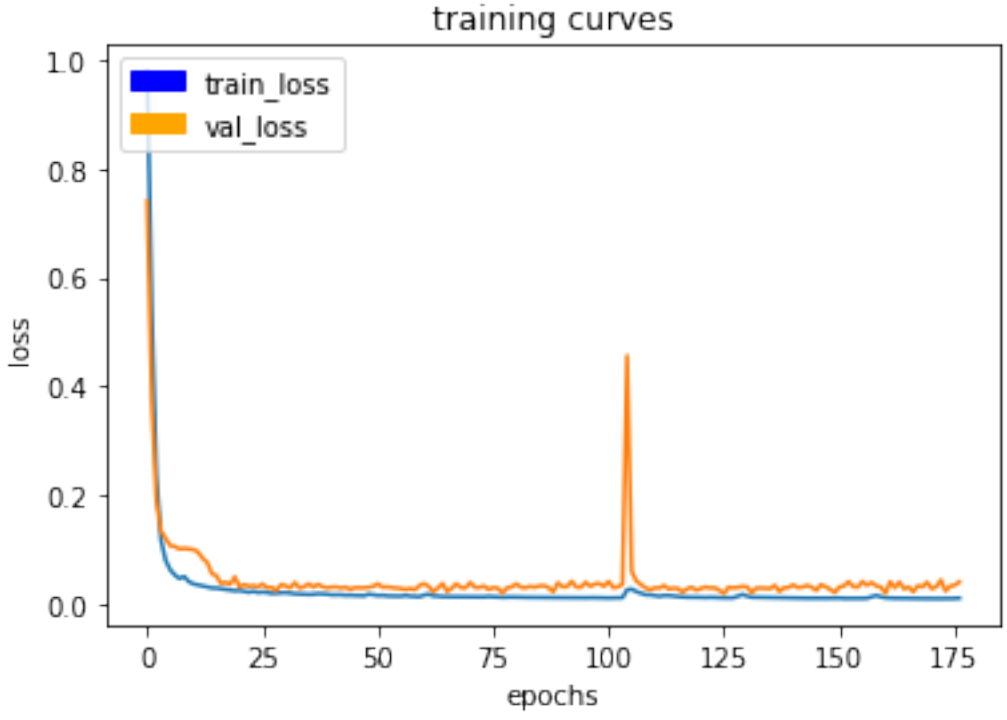
```
41/41 [==============================] - 58s - loss: 0.0102 - val_loss: 0.0238
Epoch 175/200
40/41 [============================>.] - ETA: 1s - loss: 0.0099
```



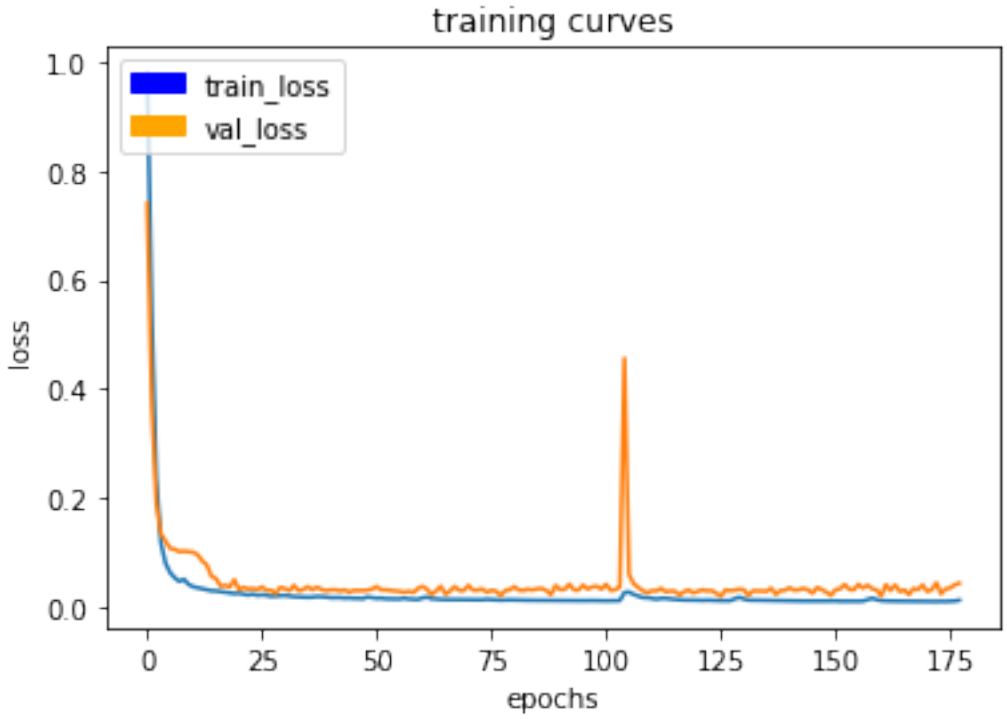

```
41/41 [==============================] - 57s - loss: 0.0099 - val_loss: 0.0328
Epoch 176/200
40/41 [============================>.] - ETA: 1s - loss: 0.0105
```



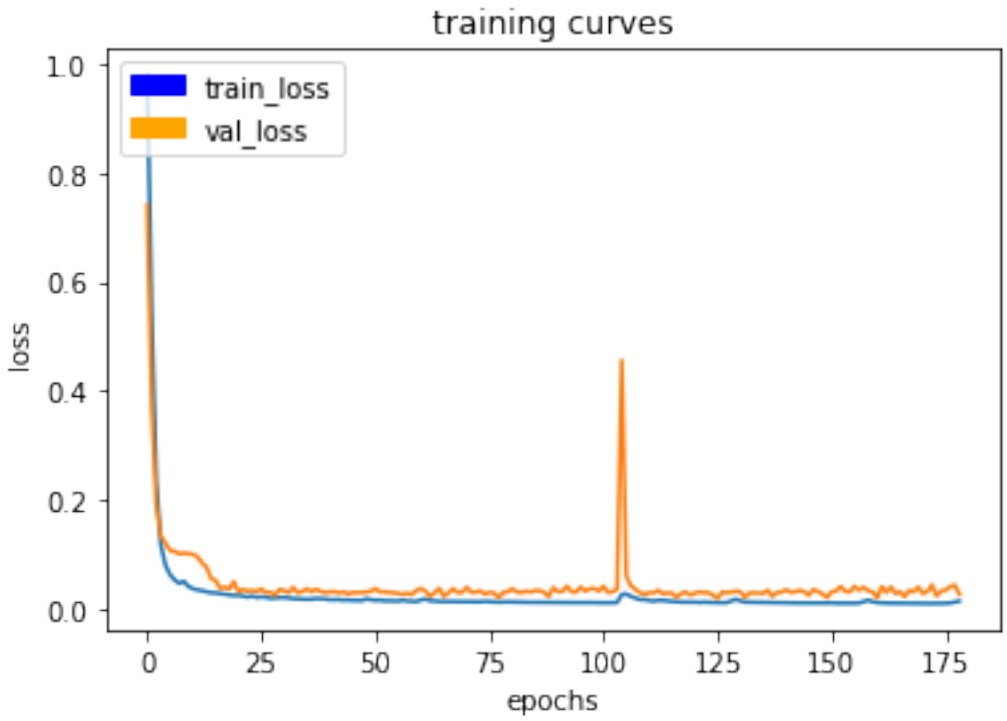

```
41/41 [==============================] - 57s - loss: 0.0104 - val_loss: 0.0345
Epoch 177/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0107
```



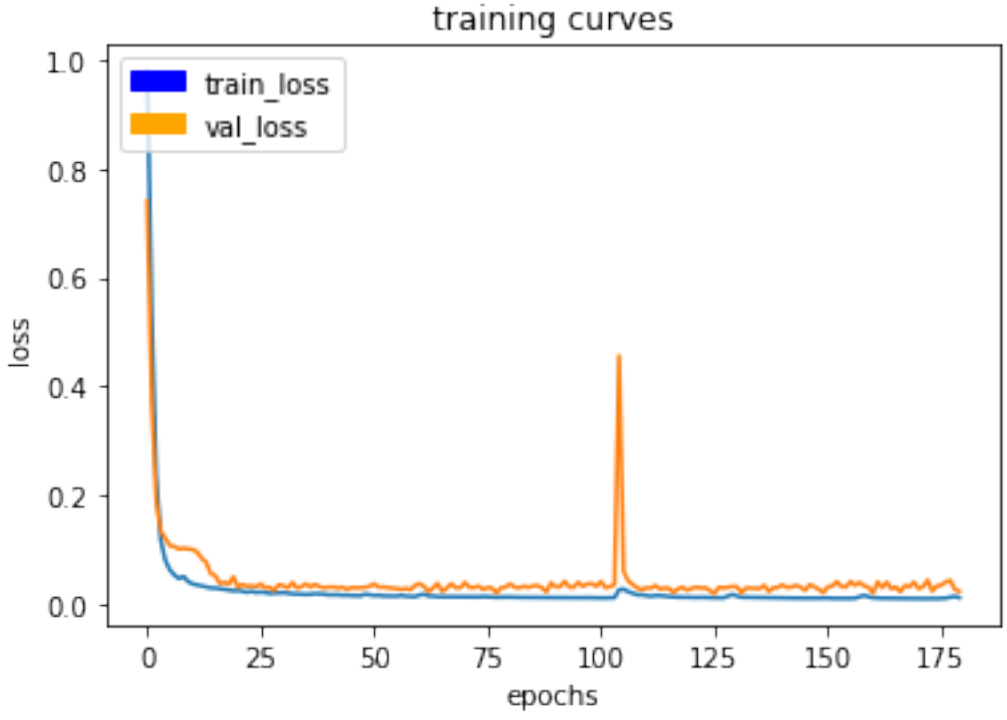
```
41/41 [==============================] - 58s - loss: 0.0107 - val_loss: 0.0406
Epoch 178/200
40/41 [============================>.] - ETA: 1s - loss: 0.0121
```



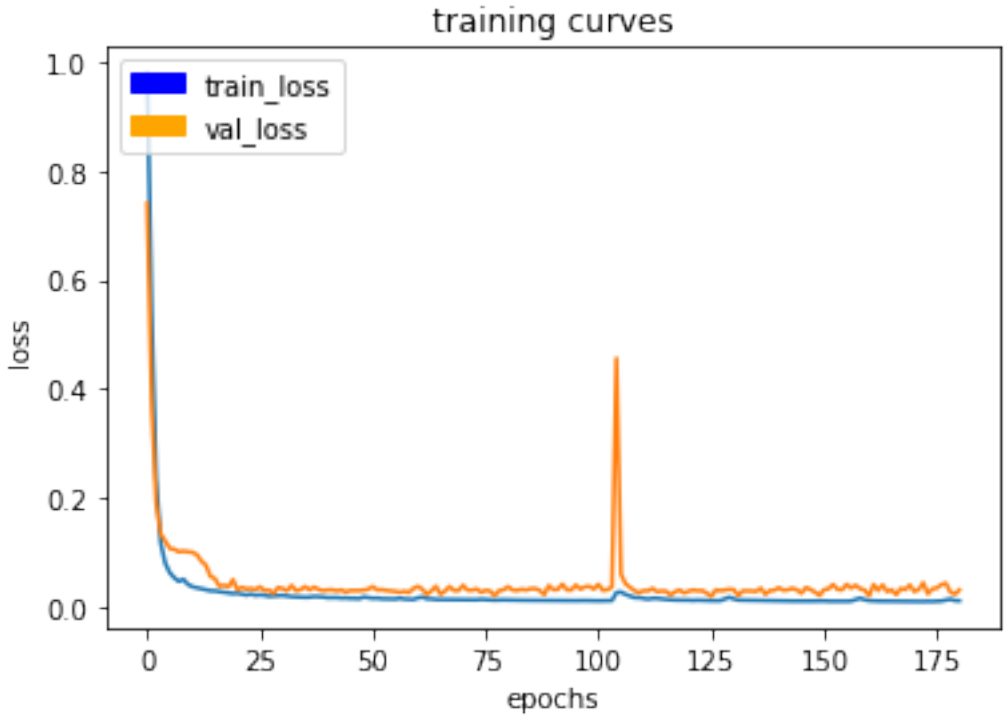

```
41/41 [==============================] - 57s - loss: 0.0122 - val_loss: 0.0434
Epoch 179/200
40/41 [============================>.] - ETA: 1s - loss: 0.0142
```



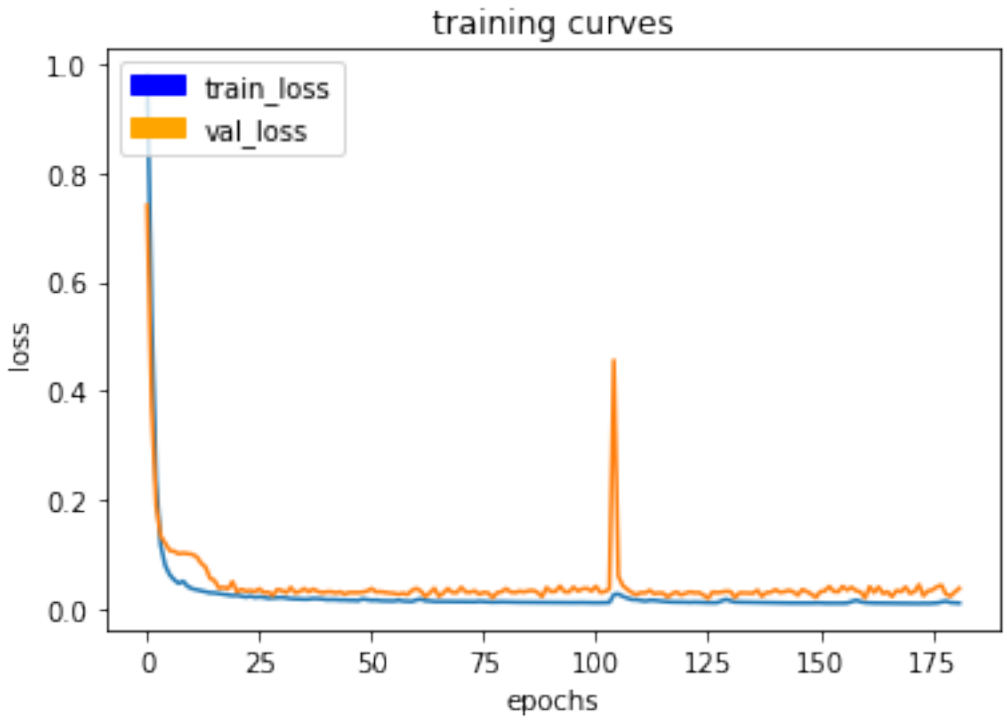

```
41/41 [==============================] - 57s - loss: 0.0142 - val_loss: 0.0270
Epoch 180/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0115
```



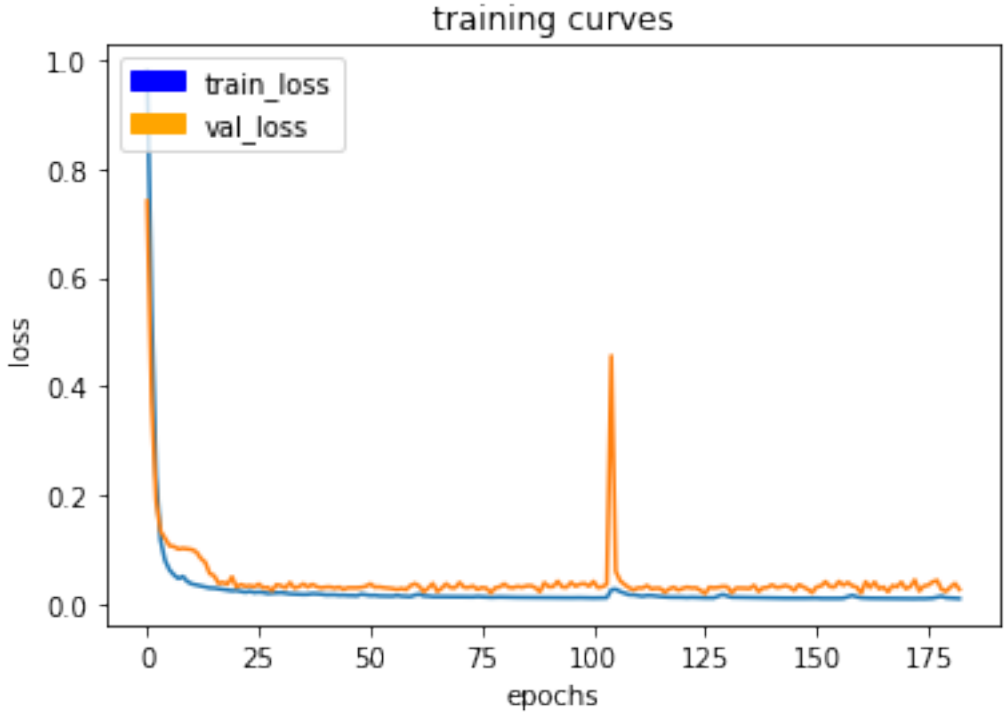
```
41/41 [==============================] - 57s - loss: 0.0115 - val_loss: 0.0233
Epoch 181/200
40/41 [============================>.] - ETA: 1s - loss: 0.0111
```



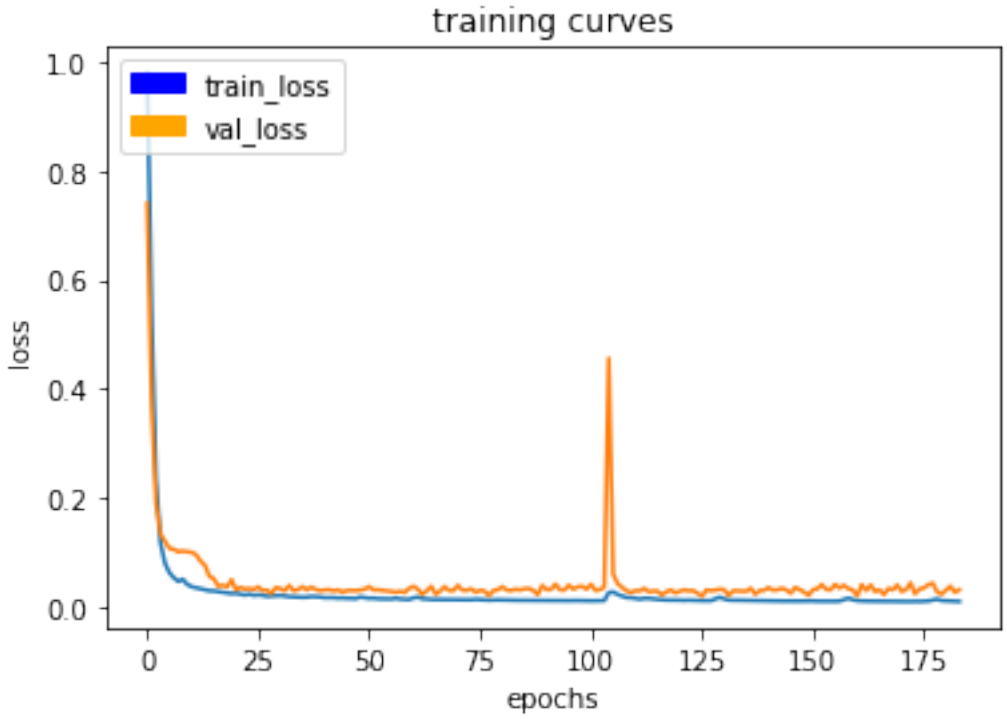

```
41/41 [==============================] - 57s - loss: 0.0111 - val_loss: 0.0309
Epoch 182/200
40/41 [============================>.] - ETA: 1s - loss: 0.0104
```



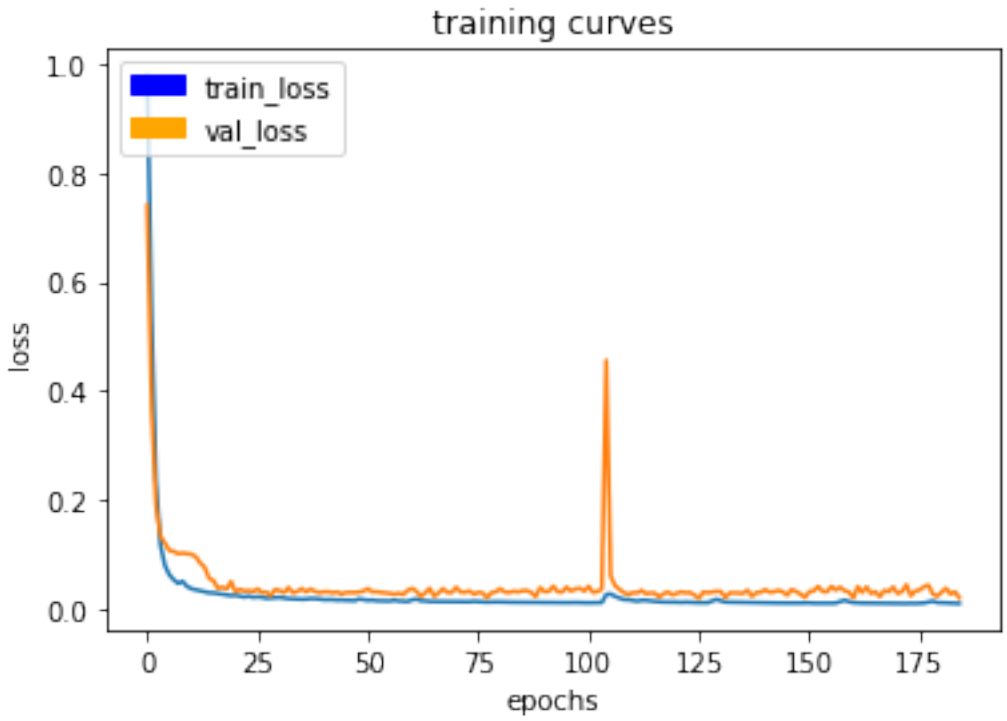

```
41/41 [==============================] - 57s - loss: 0.0104 - val_loss: 0.0377
Epoch 183/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0101
```



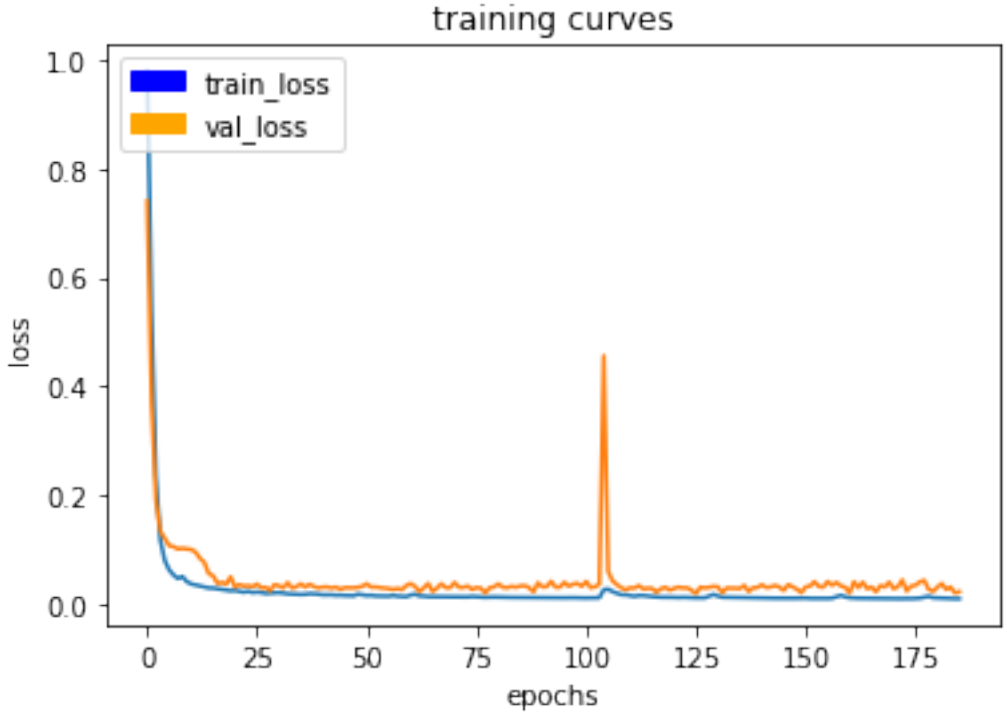
```
41/41 [==============================] - 58s - loss: 0.0100 - val_loss: 0.0268
Epoch 184/200
40/41 [============================>.] - ETA: 1s - loss: 0.0099
```



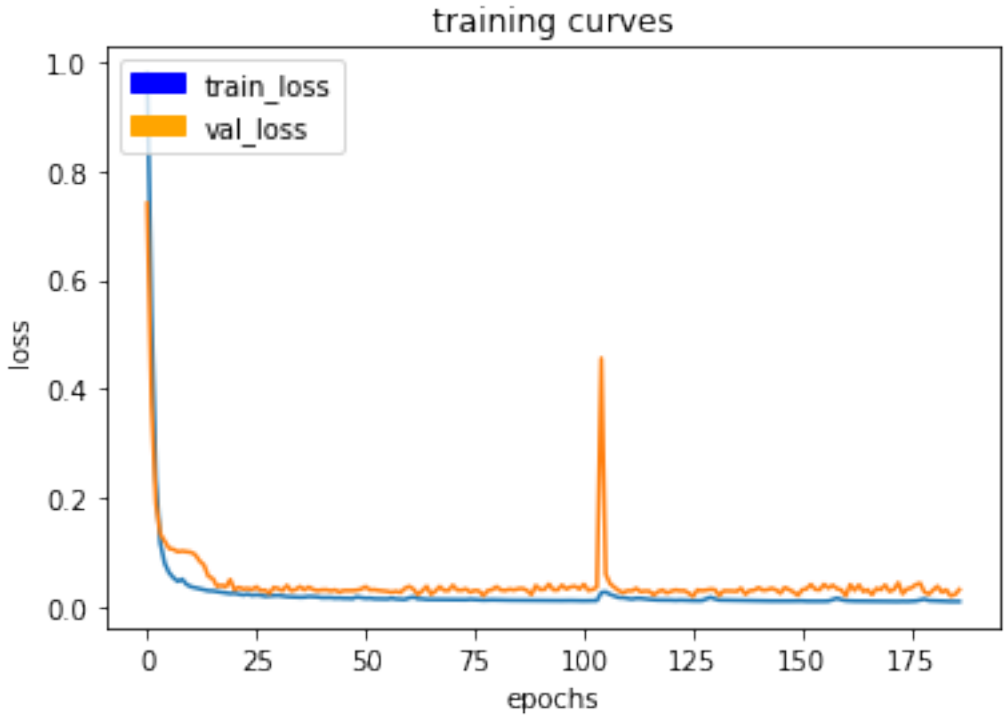

```
41/41 [==============================] - 57s - loss: 0.0099 - val_loss: 0.0312
Epoch 185/200
40/41 [============================>.] - ETA: 1s - loss: 0.0097
```



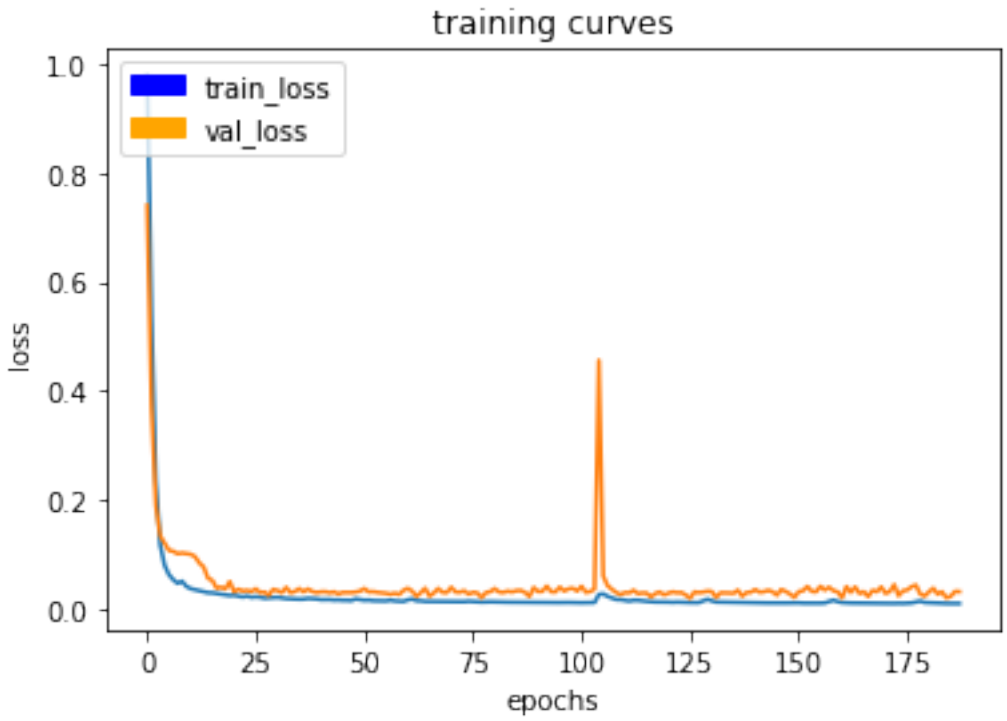

```
41/41 [==============================] - 58s - loss: 0.0098 - val_loss: 0.0200
Epoch 186/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0099
```



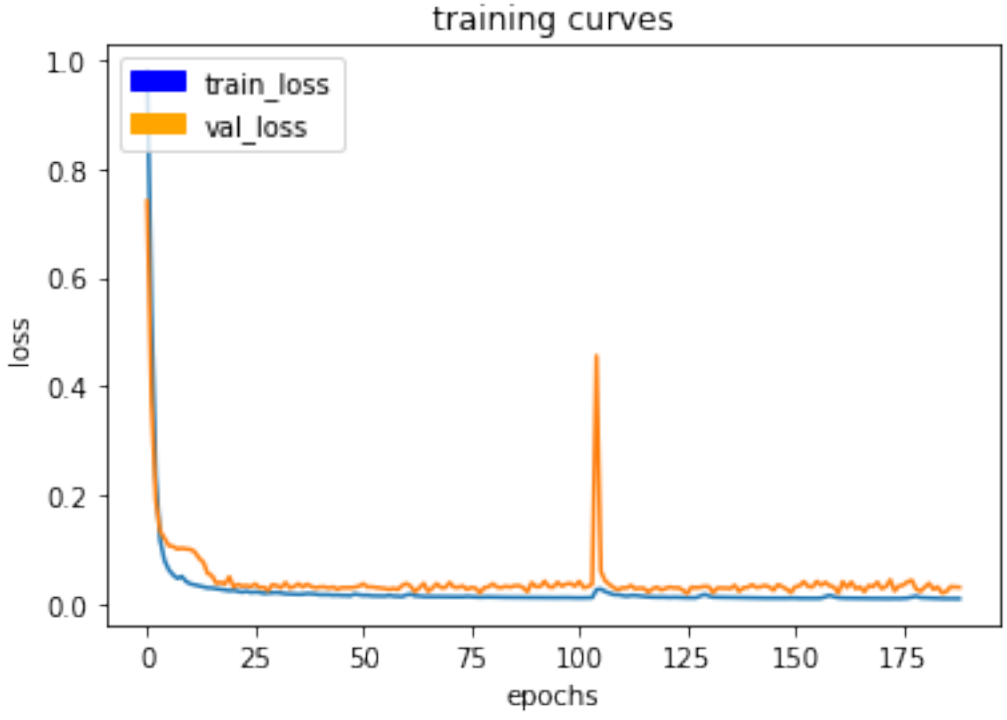
```
41/41 [==============================] - 57s - loss: 0.0099 - val_loss: 0.0227
Epoch 187/200
40/41 [============================>.] - ETA: 1s - loss: 0.0097
```



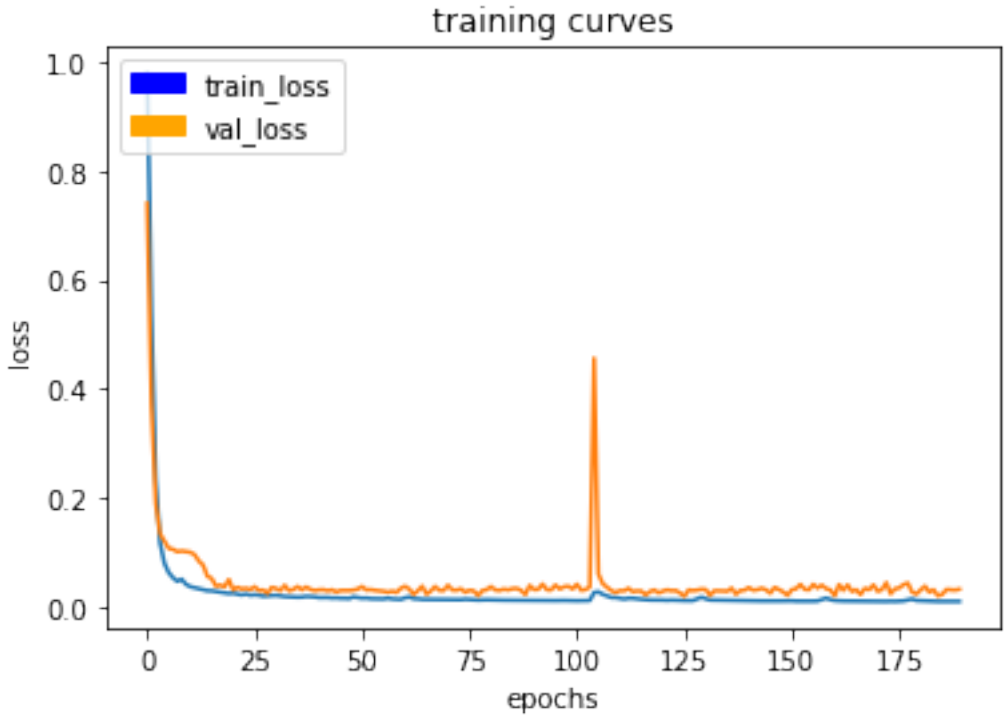

```
41/41 [==============================] - 57s - loss: 0.0098 - val_loss: 0.0317
Epoch 188/200
40/41 [============================>.] - ETA: 1s - loss: 0.0097
```



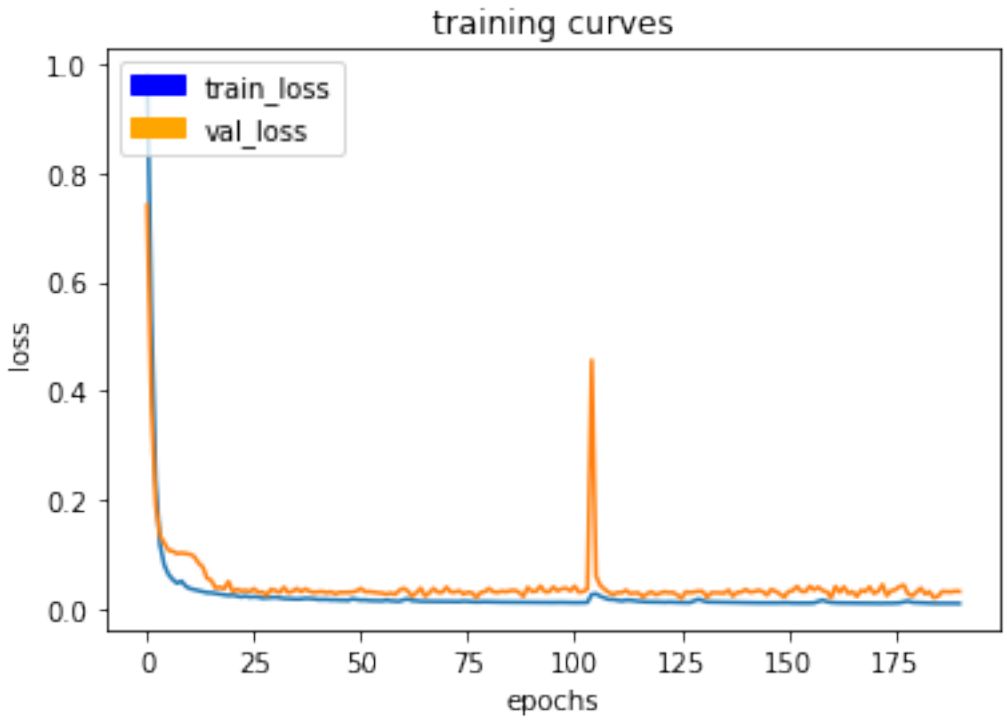

```
41/41 [==============================] - 58s - loss: 0.0097 - val_loss: 0.0313
Epoch 189/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0096
```



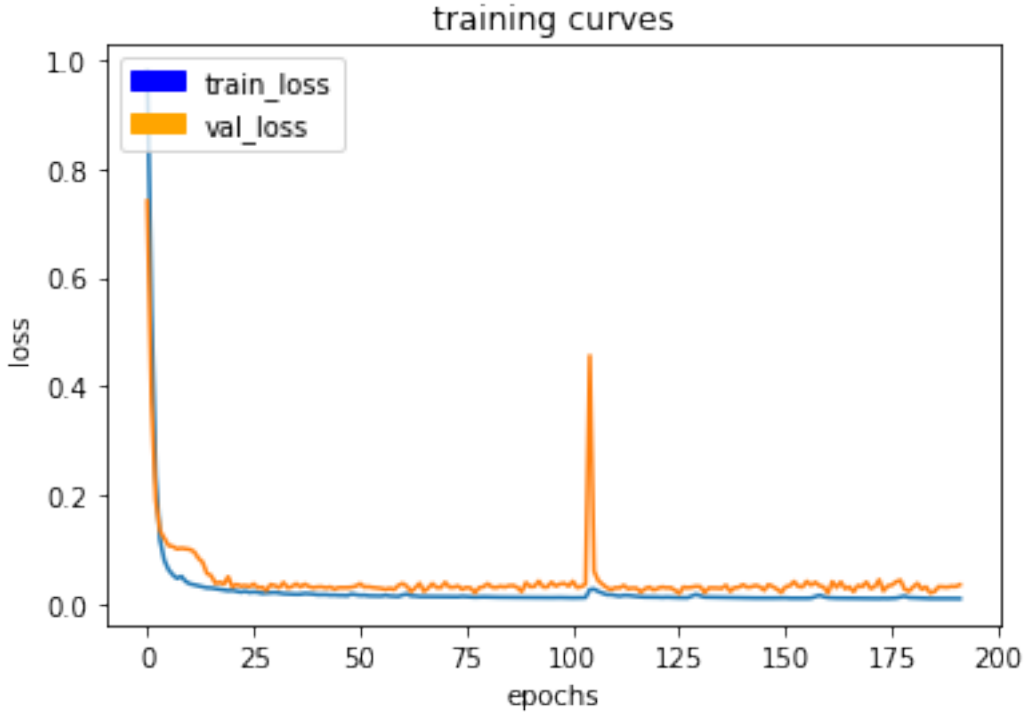
```
41/41 [==============================] - 57s - loss: 0.0096 - val_loss: 0.0305
Epoch 190/200
40/41 [============================>.] - ETA: 1s - loss: 0.0098
```



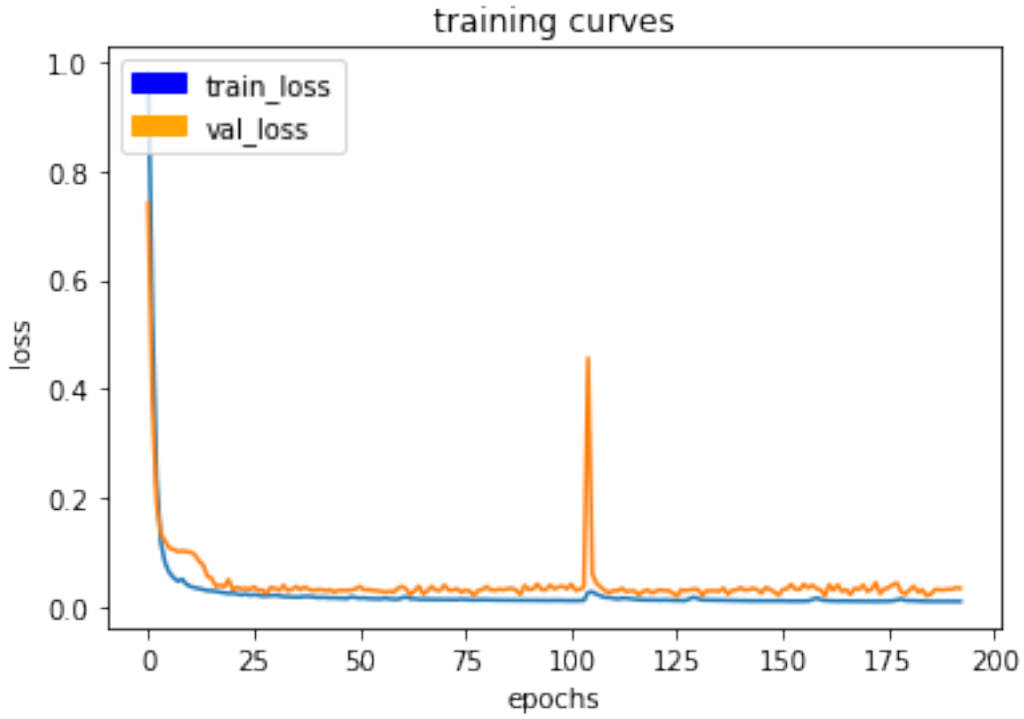

```
41/41 [==============================] - 57s - loss: 0.0098 - val_loss: 0.0322
Epoch 191/200
40/41 [============================>.] - ETA: 1s - loss: 0.0095
```



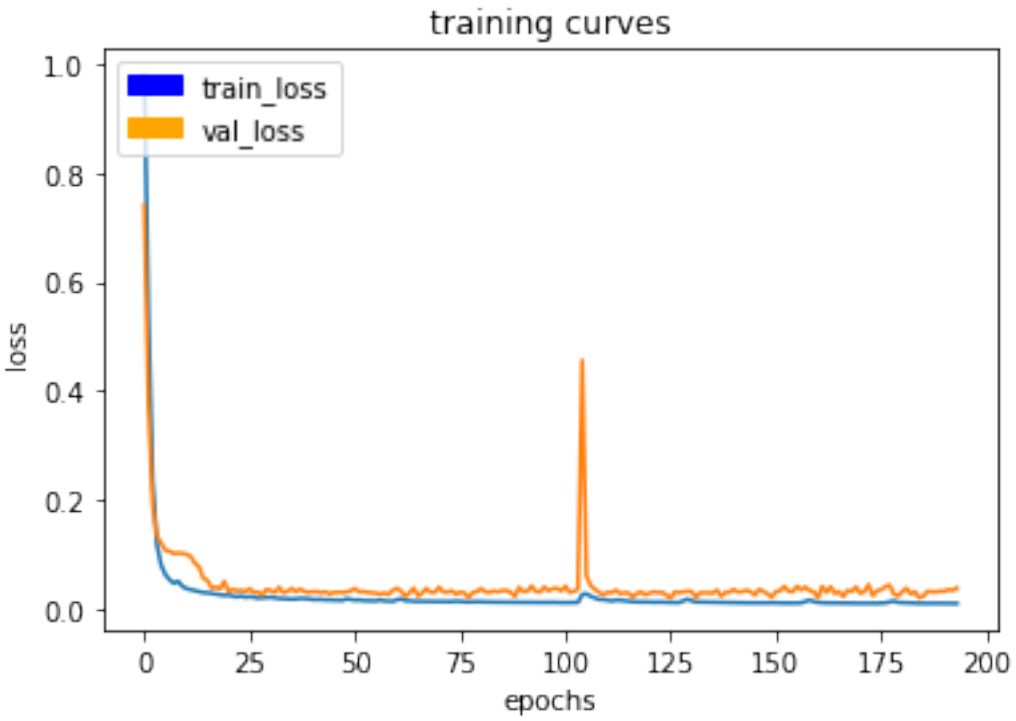

```
41/41 [==============================] - 57s - loss: 0.0096 - val_loss: 0.0317
Epoch 192/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0096
```



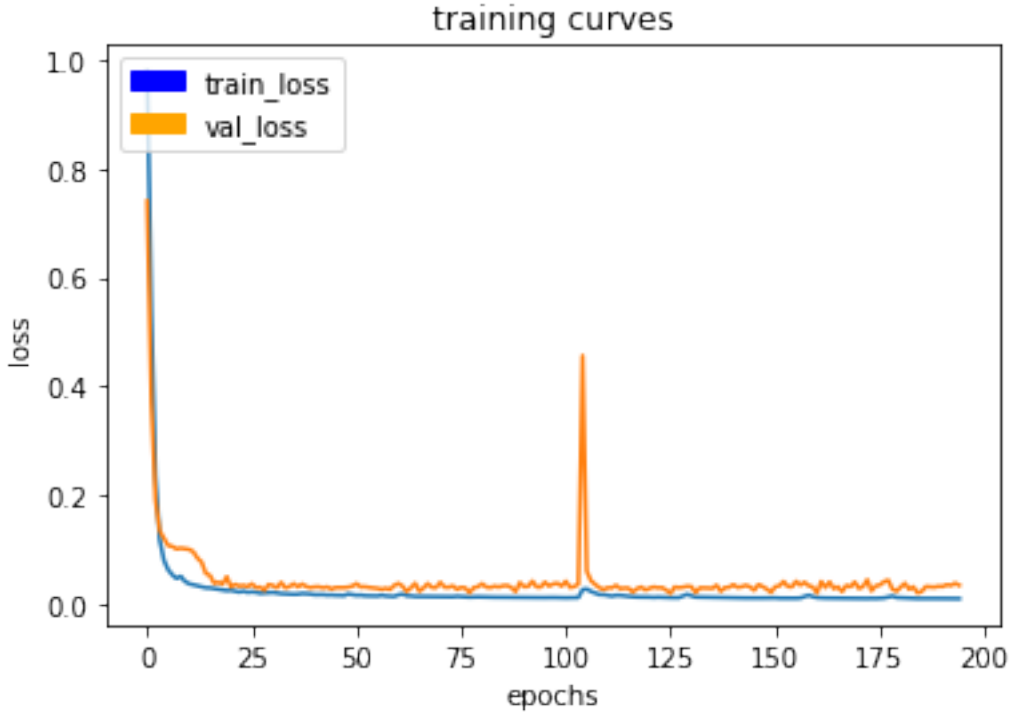
```
41/41 [==============================] - 57s - loss: 0.0096 - val_loss: 0.0351
Epoch 193/200
40/41 [============================>.] - ETA: 1s - loss: 0.0096
```



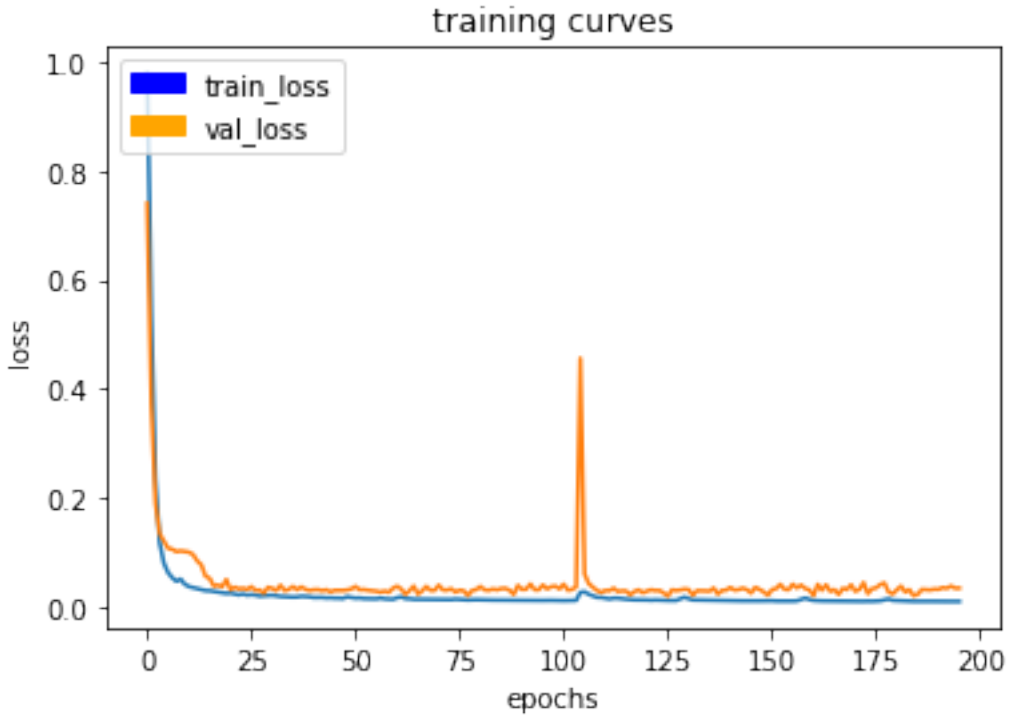

```
41/41 [==============================] - 57s - loss: 0.0096 - val_loss: 0.0337
Epoch 194/200
40/41 [============================>.] - ETA: 1s - loss: 0.0096
```



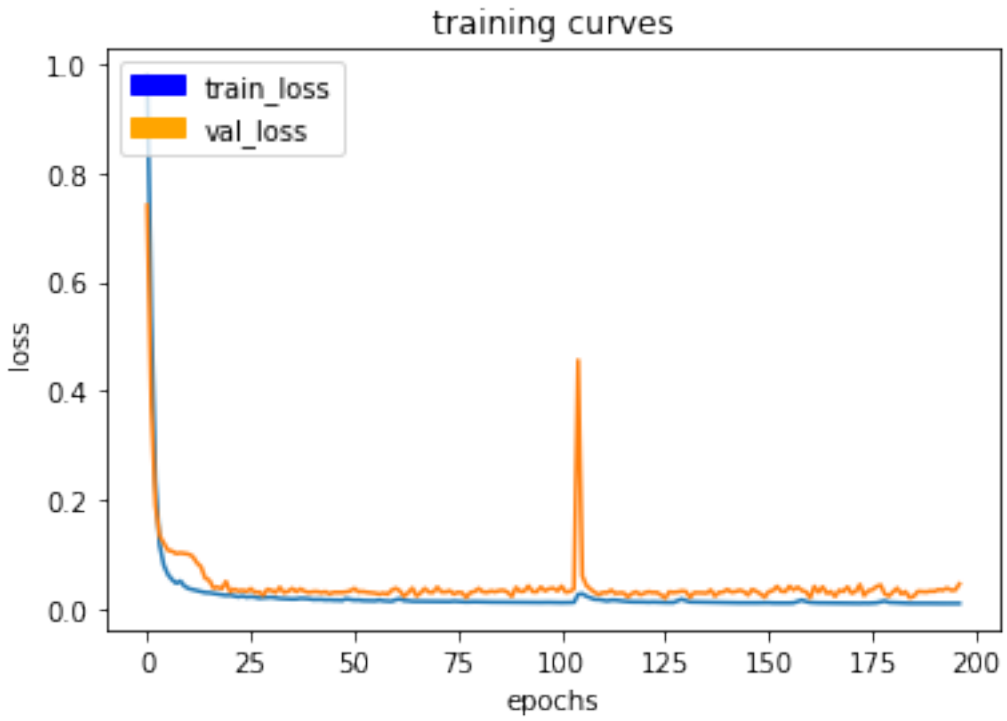

```
41/41 [==============================] - 57s - loss: 0.0096 - val_loss: 0.0379
Epoch 195/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0095
```



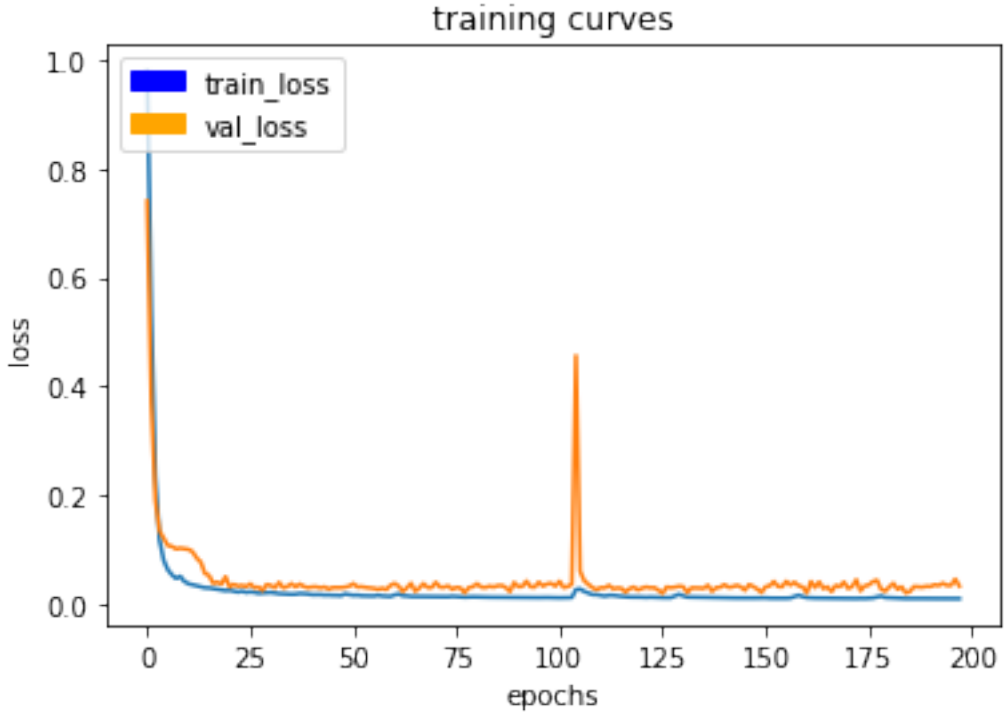
```
41/41 [==============================] - 58s - loss: 0.0095 - val_loss: 0.0338
Epoch 196/200
40/41 [============================>.] - ETA: 1s - loss: 0.0095
```



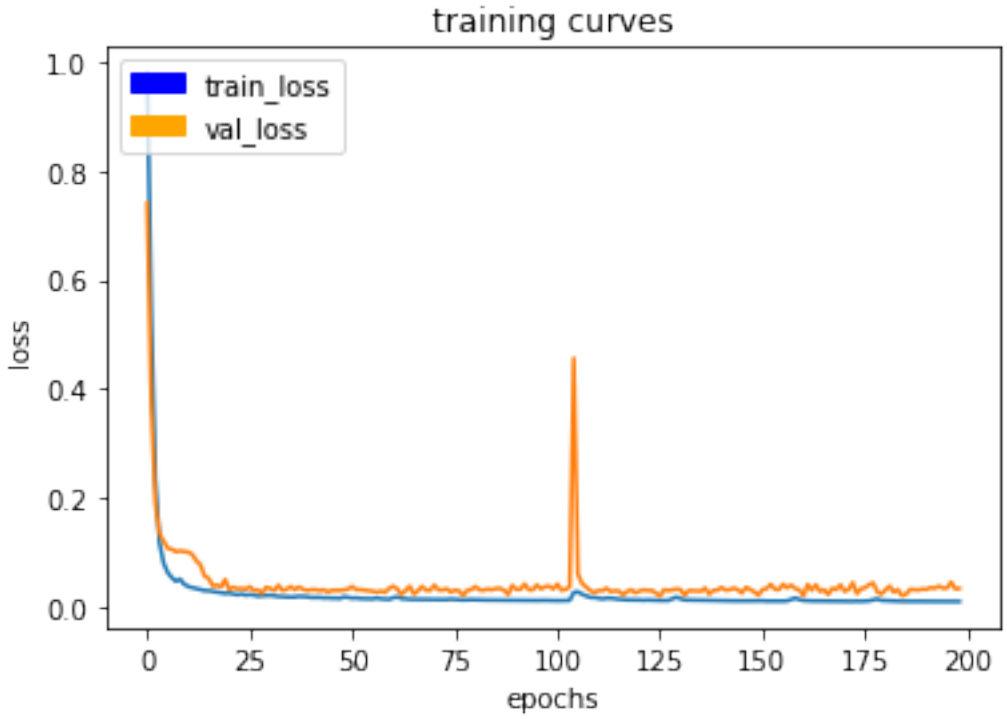

```
41/41 [==============================] - 58s - loss: 0.0096 - val_loss: 0.0341
Epoch 197/200
40/41 [============================>.] - ETA: 1s - loss: 0.0096
```



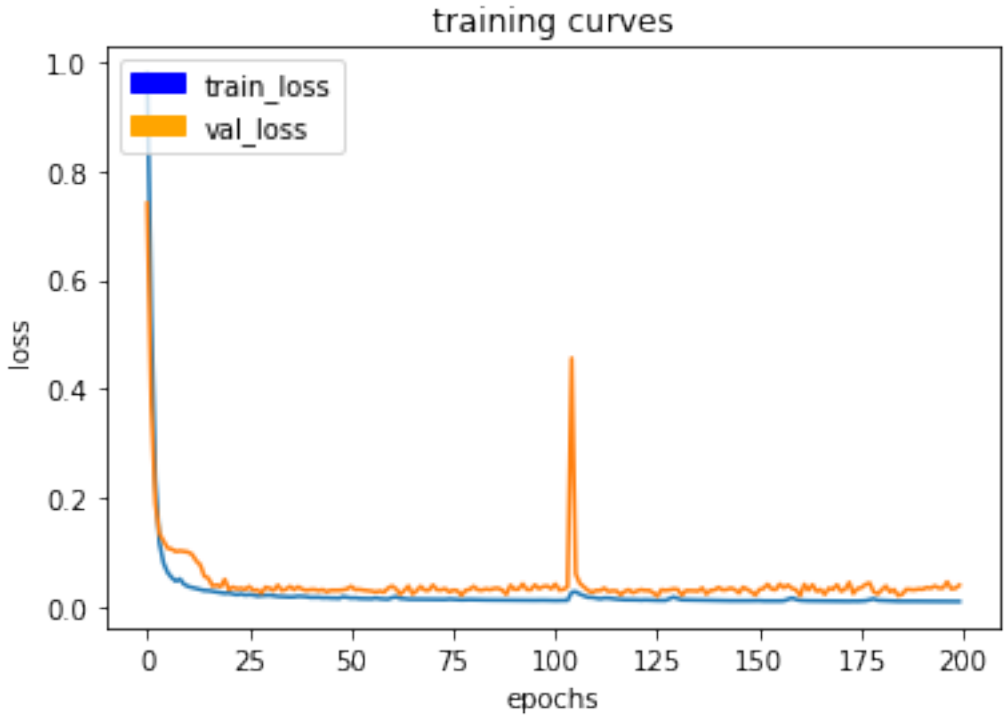

```
41/41 [==============================] - 58s - loss: 0.0096 - val_loss: 0.0453
Epoch 198/200
40/41 [==============================>.] - ETA: 1s - loss: 0.0095
```



```
41/41 [==============================] - 57s - loss: 0.0095 - val_loss: 0.0326
Epoch 199/200
40/41 [============================>.] - ETA: 1s - loss: 0.0095
```




```
41/41 [==============================] - 58s - loss: 0.0095 - val_loss: 0.0335
Epoch 200/200
40/41 [============================>.] - ETA: 1s - loss: 0.0093
```




```
41/41 [==============================] - 57s - loss: 0.0093 - val_loss: 0.0391
```

```
In [10]: # Save your trained model weights
         weight_file_name = 'model_weights'
         model_tools.save_network(model, weight_file_name)
```

1.5 Prediction

Now that you have your model trained and saved, you can make predictions on your validation dataset. These predictions can be compared to the mask images, which are the ground truth labels, to evaluate how well your model is doing under different conditions.

There are three different predictions available from the helper code provided: - **patrol_with_targ**: Test how well the network can detect the hero from a distance. - **patrol_non_targ**: Test how often the network makes a mistake and identifies the wrong person as the target. - **following_images**: Test how well the network can identify the target while following them.

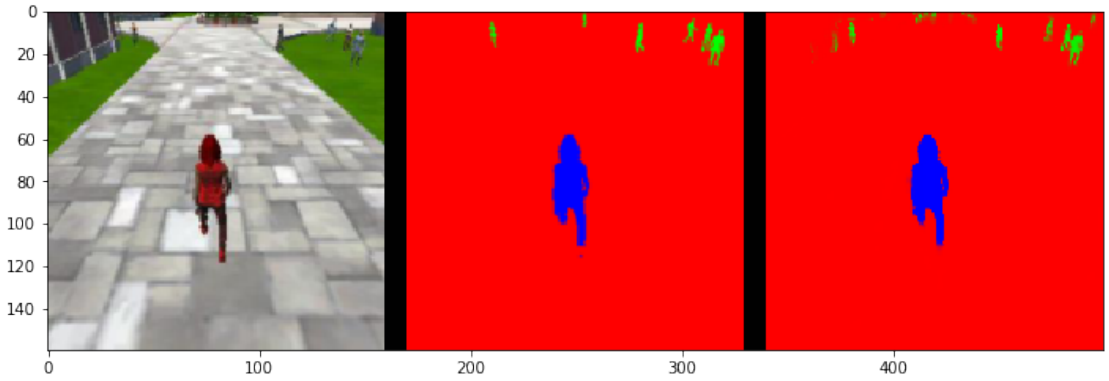
```
In [11]: # If you need to load a model which you previously trained you can uncomment the codeli

         # weight_file_name = 'model_weights'
         # restored_model = model_tools.load_network(weight_file_name)
```

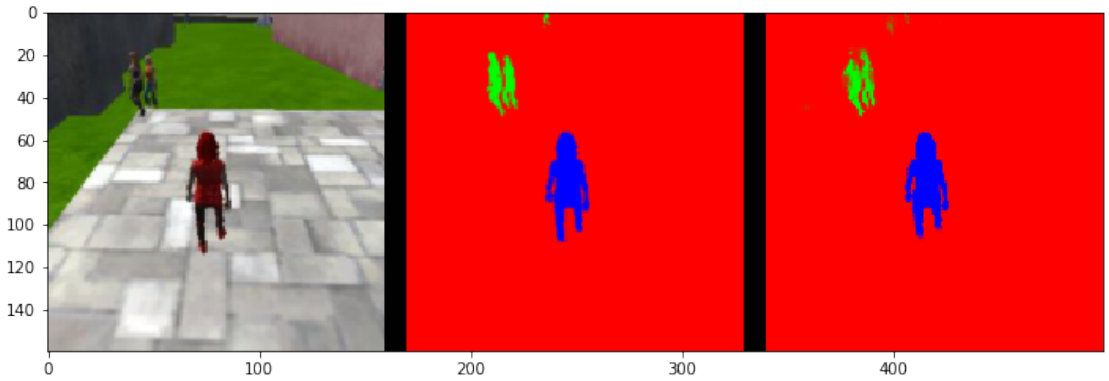
The following cell will write predictions to files and return paths to the appropriate directories. The `run_num` parameter is used to define or group all the data for a particular model run. You can change it for different runs. For example, 'run_1', 'run_2' etc.

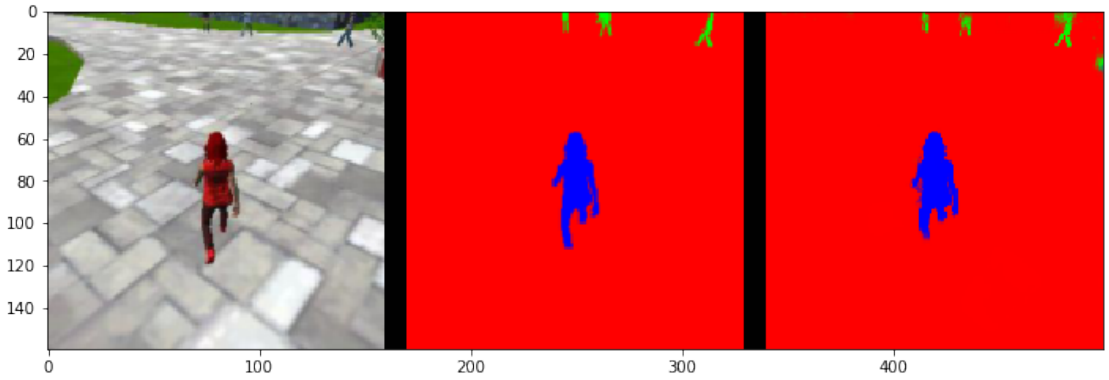
```
In [12]: run_num = 'run_1'

         val_with_targ, pred_with_targ = model_tools.write_predictions_grade_set(model,
                                                 run_num,'patrol_with_targ', 'sample_evaluation_

         val_no_targ, pred_no_targ = model_tools.write_predictions_grade_set(model,
                                                 run_num,'patrol_non_targ', 'sample_evaluation_d

         val_following, pred_following = model_tools.write_predictions_grade_set(model,
                                                 run_num,'following_images', 'sample_evaluation_
```

Now lets look at your predictions, and compare them to the ground truth labels and original images. Run each of the following cells to visualize some sample images from the predictions in the validation set.

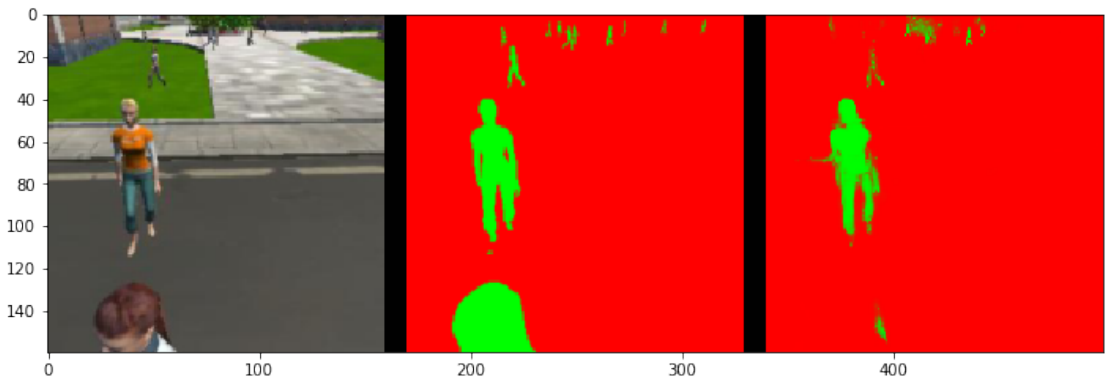
```
In [13]: # images while following the target
         im_files = plotting_tools.get_im_file_sample('sample_evaluation_data','following_images
         for i in range(3):
             im_tuple = plotting_tools.load_images(im_files[i])
             plotting_tools.show_images(im_tuple)
```

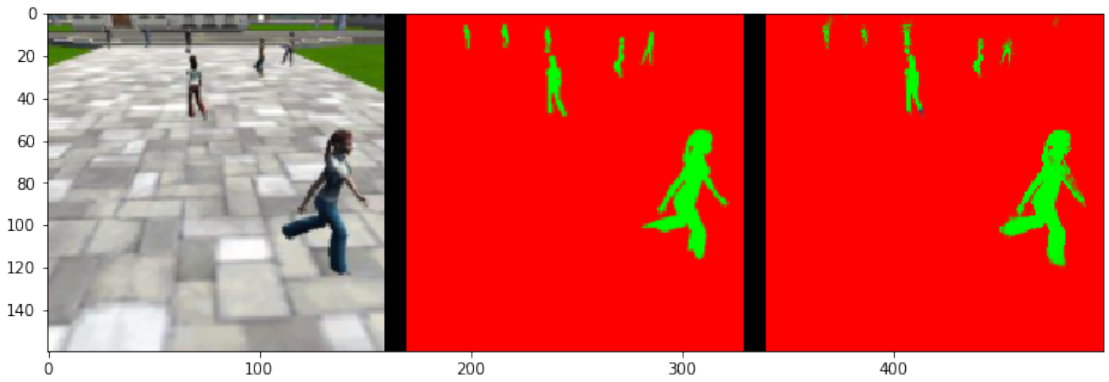


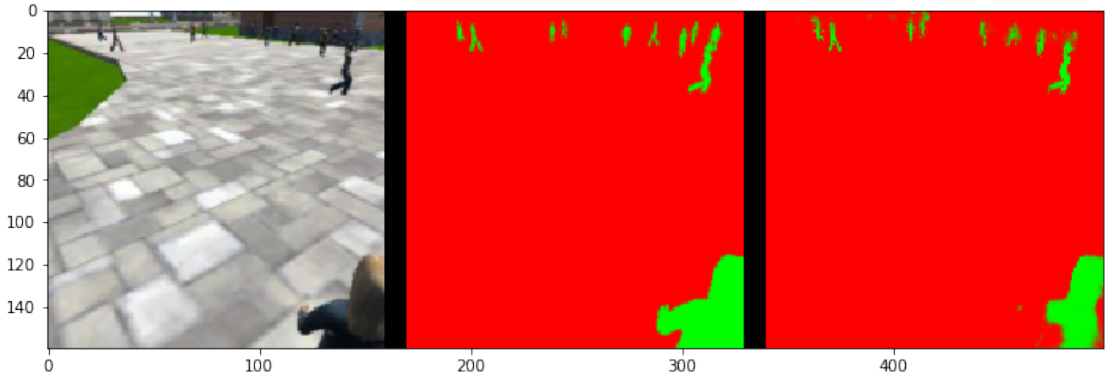




In [14]:
```
# images while at patrol without target
im_files = plotting_tools.get_im_file_sample('sample_evaluation_data','patrol_non_targ'
for i in range(3):
    im_tuple = plotting_tools.load_images(im_files[i])
    plotting_tools.show_images(im_tuple)
```

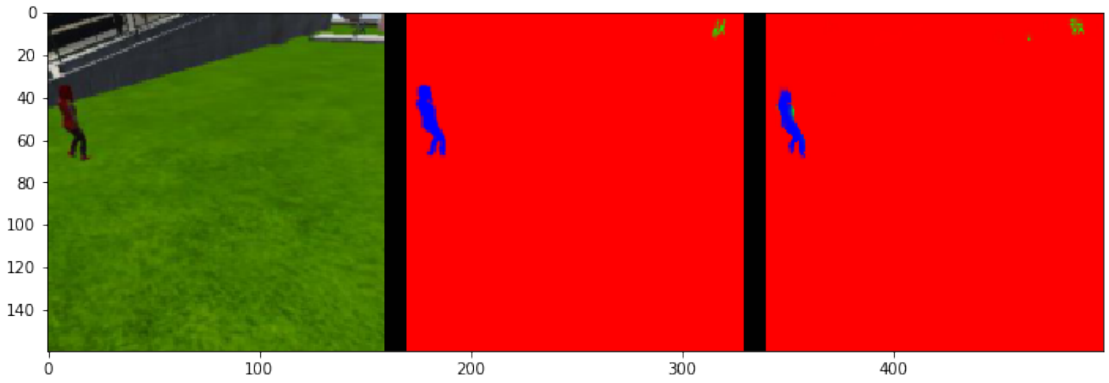


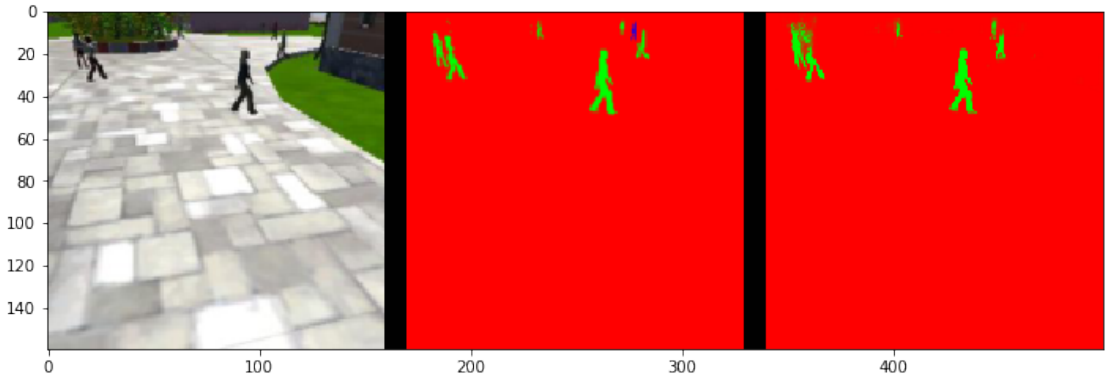


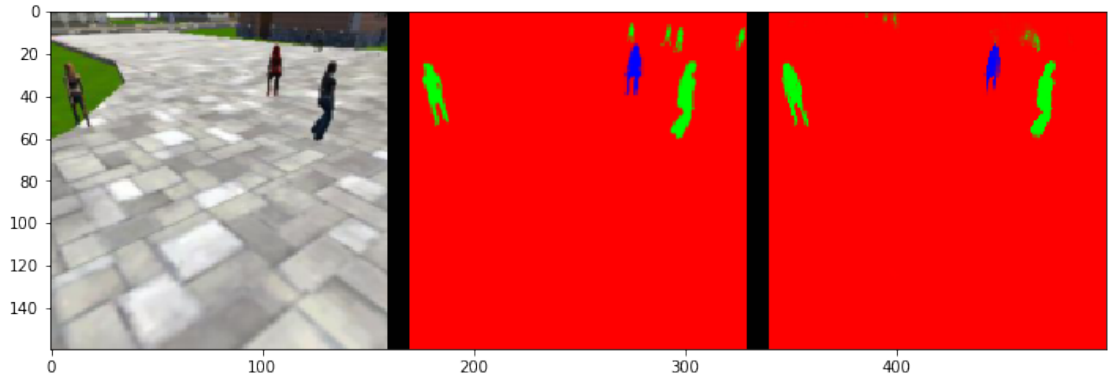


In [15]:

```
# images while at patrol with target
im_files = plotting_tools.get_im_file_sample('sample_evaluation_data','patrol_with_targ
for i in range(3):
    im_tuple = plotting_tools.load_images(im_files[i])
    plotting_tools.show_images(im_tuple)
```







1.6 Evaluation

Evaluate your model! The following cells include several different scores to help you evaluate your model under the different conditions discussed during the Prediction step.

```
In [16]: # Scores for while the quad is following behind the target.
         true_pos1, false_pos1, false_neg1, iou1 = scoring_utils.score_run_iou(val_following, pr
```

```
number of validation samples intersection over the union evaulated on 542
average intersection over union for background is 0.9956843761304677
average intersection over union for other people is 0.3562358465661956
average intersection over union for the hero is 0.9146969787739379
number true positives: 539, number false positives: 0, number false negatives: 0
```

```
In [17]: # Scores for images while the quad is on patrol and the target is not visable
         true_pos2, false_pos2, false_neg2, iou2 = scoring_utils.score_run_iou(val_no_targ, pred
```

```
number of validation samples intersection over the union evaulated on 270
average intersection over union for background is 0.9865713867317022
average intersection over union for other people is 0.7310113795759405
average intersection over union for the hero is 0.0
number true positives: 0, number false positives: 37, number false negatives: 0
```

```
In [18]: # This score measures how well the neural network can detect the target from far away
         true_pos3, false_pos3, false_neg3, iou3 = scoring_utils.score_run_iou(val_with_targ, pr
```

```
number of validation samples intersection over the union evaulated on 322
average intersection over union for background is 0.9961992915941345
average intersection over union for other people is 0.4319008679308681
average intersection over union for the hero is 0.14966698909621085
number true positives: 103, number false positives: 2, number false negatives: 198
```

In [19]:
```
# Sum all the true positives, etc from the three datasets to get a weight for the score
true_pos = true_pos1 + true_pos2 + true_pos3
false_pos = false_pos1 + false_pos2 + false_pos3
false_neg = false_neg1 + false_neg2 + false_neg3

weight = true_pos/(true_pos+false_neg+false_pos)
print(weight)
```

```
0.7303754266211604
```

In [20]:
```
# The IoU for the dataset that never includes the hero is excluded from grading
final_IoU = (iou1 + iou3)/2
print(final_IoU)
```

```
0.532181983935
```

In [21]:
```
# And the final grade score is
final_score = final_IoU * weight
print(final_score)
```

```
0.388692643557
```